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A Formative Evaluation of the Collegiate Training Initiative—Air Traffic Control Specialist (CTI-ATCS) Program

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EXECUTIVE SUMMARY

This report describes the initial formative evaluation of the Federal Aviation Administration (FAA) College Training Initiative — Air Traffic Control Specialist (CTI-ATCS) Program. The purpose of the CTI-ATCS program is to test “the concept that non-federal, post-secondary educational institutions can develop, deliver, and implement air traffic control recruiting, selection, and training programs” (FAA, 1990). The background and evolution of this program are presented, along with descriptions of the institutions that are involved in the training of CTI-ATCS participants.

The report concludes that the programs at the five participating educational institutions appear to be functioning well. Specifically, the programs are making innovations in recruitment, selection, and training that may be of benefit to the FAA. Some progress in recruiting women and minorities is being made. However, the sharply curtailed demand for controllers poses a significant challenge to the CTI-ATCS program. Improvements in program management and communications are also needed. Overall, the CTI-ATCS program appears to be generally successful, but further study is required.

FORMATIVE EVALUATION OF THE COLLEGIATE TRAINING INITIATIVE— AIR TRAFFIC CONTROL SPECIALIST (CTI-ATCS) PROGRAM

CHAPTER 1 INTRODUCTION

The present report describes an initial formative evaluation of the Federal Aviation Administration's (FAA's) Collegiate Training Initiative - Air Traffic Control Specialist (CTI-ATCS) Program. The purpose of the CTI-ATCS program is to test "... the concept that non-federal, post-secondary educational institutions can develop, deliver, and implement air traffic control recruiting, selection, and training programs" (Draft Revision of FAA Order 3120.26 dated January 16, 1991). The CTI-ATCS Program is managed by a National Steering Committee comprising representatives from Air Traffic, Human Resource Management, the FAA Academy, and the Civil Aeromedical Institute. The committee is chaired by the FAA's Higher Education and Advanced Technology Staff (AHT-30). The detailed responsibilities of these organizations with respect to the governance of the CTI-ATCS Program are described in Order 3120.26. The evolution of this program is summarized in the following section.

CTI-ATCS PROGRAM BACKGROUND

In 1988, two comprehensive studies (Means, Mumaw, Roth, Schlager, McWilliams, Gagné, Rice, Rosenthal, & Heon, 1988; Northern NEF, Inc., 1988) were undertaken to review the FAA's system for training Air Traffic Control Specialists (ATCSs). One of the more provocative recommendations of the Northern NEF study was that nonfederal, post-secondary institutions (i.e., two- and four-year colleges and universities) be selected to develop and test academic programs for training fundamental skills and knowledges related to air traffic control (ATC). The Northern NEF study acknowledged that their proposal for a collegiate training program was not a new idea. In fact, two ongoing FAA programs had been specifically designed to attract college students to ATC-related careers: The College Cooperative (Co-op) Education Program and the Airway Sciences Pro-

gram. However, both of these programs were conceived as providing training only in rudimentary ATC skills and knowledges in preparation for more in-depth training at the FAA Academy. In contrast, the collegiate program conceived in the Northern NEF report was more comprehensive, allowing graduates to bypass entry-level training at the FAA Academy and be placed directly into ATC facilities.

Different arguments have been made in favor of establishing initial ATC training programs in non-federal educational institutions. Some of these arguments were advanced in the Northern NEF (1988) study and others have evolved since then. A synthesis of arguments from that study and informal conversations with FAA personnel reveal four general justifications for the CTI-ATCS program:

1. The knowledges and skills acquired through a college education promote better performance and flexibility on the job. At a general level, a college education is thought to produce a "deeper and wider knowledge base" in ATC-related subjects, such as communications, meteorology, and aerodynamics. This knowledge base is thought to be required to cope with anticipated increases in the demands of the controller's job. At the same time, collegiate programs can address more specific educational needs, such as deficiencies in personnel management skills.

2. Additional ATC training programs expand the current pipeline of trained ATCSs. This expansion is viewed in terms of both the greater numbers required to meet staffing requirements for the National Airspace System (NAS) and in diversity to include a greater proportion of minorities and women in the profession. As staffing needs have abated in recent years, the potential of colleges to increase ATCS work force diversity has become much more important.

3. College training promotes the professionalism of the ATCS work force. It has been argued that the level of controller education should be more congruent with the

job responsibilities and civil service rank (GS-12 to -14) of an air traffic controller. Also, consistent with other professions, students should bear a significant portion of the cost of their own education. A corollary to this argument is that the CTI-ATCS program can potentially reduce the costs to the federal government for entry-level ATCS training.

4. Collegiate programs tap technical training expertise available at colleges and universities to develop innovative approaches to training. These approaches include improvements to training systems (analysis, design, development, implementation, and evaluation), as well as the employment of specific advanced training technologies (e.g., computer-based tutorials and simulations).

In response to agency and congressional interest in the potential of collegiate ATC programs, the FAA entered into a cooperative agreement with the Mid-America Aviation Resource Consortium (MARC) in February 1990 for the establishment of an ATC training program in Minnesota. The FAA was directed in its FY 1990 appropriation (P.L. 101 - 164 [H.R. 3015], November 21, 1989) to provide \$3.4 Million to MARC. Similarly, the FAA provided a grant of \$5 Million to Hampton University (HU) in 1990. Continued interest in the program led the FAA to formally establish the CTI-ATCS program in January 1991 and to solicit the participation of additional schools. To be selected for the CTI-ATCS program, post-secondary institutions were required to submit formal proposals. The FAA rated the proposals they received on a number of factors, such as capability to develop a valid ATC training program, the employment of advanced training methodologies, and strategy for aggressively recruiting minority and female students. Three additional schools were selected in 1991, bringing the total to five institutions:

1. Minnesota Air Traffic Control Training Center (MnATCTC), Eden Prairie, MN;
2. Hampton University (HU), Hampton, VA;
3. Community College of Beaver County (CCBC), Monaca, PA;
4. University of North Dakota (UND), Grand Forks, ND; and
5. University of Alaska, Anchorage (UAA), Anchorage, AK.

These five institutions have developed substantially different approaches to ATCS recruiting, selection, and training. In fact, the programs themselves were initially selected to be highly diverse in at least two respects. First, the institutions are geographically dispersed, allowing the CTI-ATCS program to draw from a large and diverse population of potential ATCS candidates. For instance, UND and UAA are geographically well suited to recruiting from Native American populations, whereas HU recruits from an urban center that has large numbers of African American and other minority inhabitants. Second, the selected institutions themselves are markedly different in affiliation and charter. The institutions include two public universities (UND and UAA), a privately endowed, historically black university (HU), a two-year, private community college (CCBC), and a non-degree, six-month technical training program (MnATCTC).

The diversity in approaches to ATCS training is consistent with the FAA's desire for the CTI-ATCS programs to devise innovative approaches to recruiting, selecting, and training. At the same time, however, the diversity of programs makes evaluation more difficult. Clearly, the programs should not be directly compared to determine "the best" approach. Rather, the present approach assumes that there are certain fundamental goals and objectives that every CTI-ATCS program must address. At the same time, it acknowledges that the approaches or processes used to achieve those goals may be substantially different across programs.

EVALUATION OBJECTIVES

As a member of the steering committee for the CTI-ATCS program, the FAA's Civil Aeromedical Institute (CAMI) is tasked with monitoring and evaluating the program. The present research is part of this ongoing evaluation effort. The specific objectives of this initial formative evaluation are to determine the degree of innovation that the five selection institutions demonstrate with regard to their (a) recruiting activities, (b) selection procedures, and (c) training methods. This research is part of an larger evaluation strategy that calls for a future summative evaluation of

program outcomes defined in terms of the progress of CTI graduates in field training and the success of the graduates on the job.

ORGANIZATION OF REPORT

The next chapter of the report (Chapter 2) provides a description of the methods used to perform the present evaluation. Chapter 3 describes various as-

pects of the programs in terms of their progress in recruiting, selecting, and training students. Chapter 4 presents our conclusions and recommendations about the CTI-ATCS program as it presently stands.

CHAPTER 2 METHOD

Each of the five individual CTI-ATCS programs was examined using a formative evaluation approach. Formative evaluation is usually defined in contrast to summative evaluation, the purpose of which is to provide inferences about the outcomes of programs. A summative evaluation usually concerns quantitative outcomes, such as the success of CTI-ATCS graduates on the job, as measured by their rate of progress in on-the-job training (OJT) at field facilities, or scores on job performance evaluations. To produce these sorts of outcome data, however, a program must be fully implemented and stable for a considerable period of time. The five CTI-ATCS programs, in contrast, have only just started to produce graduates: Only 61 graduates were hired during the first 18 months of the program. Consequently, a summative evaluation of the program would be premature at this point.

Whereas summative evaluations focus on program outcomes, formative evaluations examine (and hopefully, improve) program processes at the early stages of program implementation. Another contrast is that the data collected in formative evaluations are usually qualitative in nature. As originally differentiated by Scriven (1967), however, formative and summative methods are not alternative methods; rather, they are complementary approaches in a comprehensive evaluation strategy. The qualitative observations and speculations of formative evaluation are seen as a necessary first step in generating hypotheses to be tested in the summative evaluation phase. Thus, the present findings should be viewed as the initial phase in a continuing evaluation process.

CTI-ATCS SITE VISITS

Morrison and Fotouhi visited each of the five participating CTI-ATCS programs in May and June 1993. At each site, the evaluators collected and discussed program literature describing the programs, such as catalogues and promotional materials. They also examined training facilities. The evaluators were able to observe classes in session only at CCBC and MnATCTC because the school year had already ended at the other three program sites. At each site, evaluators conducted interviews with key program person-

nel including administrators, instructors, and students when available. (Interview protocols are included as an Appendix.) Students were not available for interviews at HU and UAA. Also, none of the instructors at UAA were available because they are on campus only during the regular school year.

In addition to visits to the five CTI-ATCS sites, a visit was made to the FAA Academy to acquire background information for the evaluation and to examine the Academy terminal and en route training programs. It is important to note that the FAA Academy is not a subject for evaluation in the present report. Rather the Academy was intended to serve as a "benchmark" against which the individual CTI-ATCS programs could be compared. The Academy training program is discussed only as a point of reference for describing CTI-ATCS programs.

EVALUATION TOPICS

Administrators of the CTI-ATCS programs were questioned about their programs to probe their perceptions of program goals. Some questions were asked at the end of the interview to obtain more subjective impressions about the program as a whole, such as the perceived strengths and weaknesses. Most questions, however, were designed to provide factual information concerning three broad topics, each of which is discussed below.

Recruitment

Administrators of the five CTI-ATCS programs were asked to describe the overall approach they used to attract students to their programs. In addition to this general question, two specific recruitment issues were pursued in depth. The first issue was how the institutions attracted students to a collegiate program where students may have to pay their own tuition and living expenses, compared to the FAA Academy, where students are paid as GS-7 government employees while attending a tuition-free program. In this context, the program administrators were asked to estimate tuition and other costs that are borne by the students. The second issue was to determine the institution's strategy to attract women and minorities.

The institutions were also requested to provide data to substantiate their progress in this regard.

Selection

Pre-Training Screen

From the outset of the program, all CTI-ATCS students have been required to take the 4-hour written ATC examination administered by the U.S. Office of Personnel Management (OPM). This test is designed to identify those applicants who have aptitude for the ATC profession and to select students for the FAA Academy. The individual CTI-ATCS programs were originally required to develop "additional" methods for selecting students who demonstrate aptitude for the ATC profession. The original goal was to develop a cost-effective method to replace the 9-week screening process at the FAA Academy. Recently, however, the FAA has developed a 5-day, computer-administered Pre-Training Screen (PTS) to select ATCS students immediately prior to the beginning of training.

FAA validation studies, as reported by Broach and Brecht-Clark (1993), indicated that the PTS was successful in predicting outcomes in the FAA Academy Nonradar Screen as well as progress in on-the-job training at field facilities. There were suggestions in May 1993 that all CTI-ATCS students would be required to take the PTS battery as a condition of employment by the FAA. The plan, at that time, called for students to travel to the FAA Office of Aviation Careers Assessment Center, located at the Mike Monroney Aeronautical Center in Oklahoma City, to take the PTS at some point prior to employment by the FAA. The FAA was to assume student travel and lodging costs. However, in a letter to the CTI institutions dated December 22, 1993, the FAA's Assistant Administrator for Human Resources Management "suspended" the requirement that the CTI-ATCS graduates successfully complete the PTS.

The evaluators also sought to identify any other admission requirement that effectively selected students for the program. In that regard, the institutions were asked to characterize their "typical" students demographically to obtain an impression of the outcome of both the recruiting and selection processes.

Performance Verification

Upon completion of training, the FAA plans to require all CTI-ATCS students to submit to "Performance Verification" (PV), an evaluation process confirming that students have acquired the basic competencies needed to start field training at an ATC facility. PV has two components: (a) a knowledge component assessed by traditional (i.e., paper-and-pencil) methods; and (b) a performance component, which is conceived as a simulated, but realistic, ATC exercise designed to assess those skills and knowledges. At the outset of the CTI-ATCS Program, the individual institutions were initially required to develop both components of PV that could be administered within the objectives and resources of their particular programs.

More recently, the FAA has moved to standardize the performance component of PV across CTI-ATCS programs and the FAA Academy to ensure that controllers attain the same minimally acceptable level of performance before assignment to a field facility. Responsibility for PV for both the Academy and the CTI-ATCS programs was assigned to a single FAA division (ATZ-400). With regard to the performance component, it is the responsibility of ATZ-400 to establish PV requirements in the form of simulation scenario events (e.g., numbers of aircraft, types of aircraft, weather) for both terminal and en route versions of the examination. The individual programs are required to develop a simulation scenario using their own resources to meet these PV requirements. The institutions administer PV locally, with ATZ-400 monitoring the testing process. This new PV concept was agreed upon in March 1993, and ATZ-400 provided PV requirements for both en route and terminal options in August 1993 (Manger, Training Requirements Program, & Manager, Performance Verification Program). Because of this recent change in concept, the institutions had not incorporated PV into their curriculum at the time of the evaluation. Nevertheless, program administrators were asked to comment on the PV program and how it might be implemented at their institution.

Training

To gain a concept of the overall goal of ATC training at each of the institutions, the evaluators asked program administrators to define the level of job performance that their graduates are expected to attain as the result of training. For terminal ATCSs, this is usually described in terms of the number of operations per hour, which can be translated to terminal level. For instance, the goal of FAA Academy tower training is to produce students who are able to handle 60-65 operations per hour, the equivalent of a Level III facility. In contrast, the final objective for the en route program at the FAA Academy is stated in terms of fulfilling a particular en route job. As an example, the goal of FAA en route training is to produce a student who is a qualified Radar Associate, that is, completed Phase VIII of the 1988 Instructional Program Guides (IPGs). The 1988 IPG (p. VIIIA-3) requires that at completion of Phase VIII, "the developmental will, in accordance with Handbook 7110.65:

1. Identify duties of the radar-associated/nonradar position;
2. Identify aircraft, permanent echoes, weather, etc. on radar displays;
3. Define beacon code assignments;
4. Describe radar identification procedures;
5. Describe transfer of radar identification procedures and standard operating practices;
6. State radar separation minima;

7. Identify when to integrate the use of nonradar procedures into a radar environment to ensure positive separation;
8. Describe procedures for verifying and using Mode C;
9. State procedures for issuing IFR clearances using radar and nonradar data for departure and airfiles;
10. Enter computer messages for a radar-associated/nonradar position;
11. State the transition procedures to and from the primary back-up system; and
12. State the requirements for position relief briefings."

Two specific training issues were pursued in detail. The first was to describe the curriculum and the methods by which it was developed. In particular, evaluator questions were directed toward uncovering any task analytic and training design models that were used to develop the ATC curriculum. The second issue was the identification of innovative training technologies that were in place or planned. Innovative technologies included instructional procedures (e.g., team training) or instructional delivery systems (e.g., multi-media machines).

Another aspect of training pursued by the evaluators was the number of trainers and their background. A crucial issue pursued was the currency of instructor's experience. The FAA assigns active ATCSs as instructors in the Academy. The concern was that CTI-ATCS instructors were substantially less current in their knowledge of current ATC rules, regulations, and techniques.

CHAPTER 3 PROGRAM DESCRIPTIONS

This chapter presents results from the interviews. The answers are organized as descriptions of the individual CTI-ATCS programs. These essentially qualitative but objectively verifiable descriptions provide a common basis from which the individual programs can be compared and contrasted. Evaluative comments on all five programs are provided in Chapter 4.

This chapter is divided into five sections corresponding to each of the five CTI-ATCS institutions. Each section is divided into two subsections. The first subsection (Students) describes the sorts of students that have been recruited and selected in the programs, thereby integrating those two evaluation topics. In addition, the first subsection includes the specification of tuition costs incurred by students. The second subsection (Program of Instruction) contains a discussion of training issues, including detailed descriptions of curricula, instructional laboratories, class size, and instructors. This framework permits comparisons of the instructional programs at each of the five institutions. In addition, the descriptions highlight any major aspect of recruitment, selection, or instruction that is unique to a particular program.

MINNESOTA AIR TRAFFIC CONTROL TRAINING CENTER

The Minnesota Air Traffic Control Training Center (MnATCTC) is located at the Flying Cloud Airport in Eden Prairie, MN, which is about 15 miles west of Minneapolis. Unlike other CTI-ATCS programs, MnATCTC is not located on or directly associated with an educational institution. However, in partnership with the Minnesota Department of Transportation, MnATCTC has a consortium agreement with several educational systems, including the University of Minnesota, the Minnesota State University System, the Minnesota State Board for Community Colleges, the Minnesota State Board of Technical Colleges, and the Minnesota Higher Education Coordinating Board, through the Mid-America Aviation Resource Consortium (MARC).

MnATCTC was the first institution to be selected for the CTI-ATCS demonstration program. In February 1990, the FAA entered into a cooperative agreement with the Minnesota Department of Transportation to develop and administer a prototype six-month non-degree ATC program. The first (pilot) class began in January 1991. At the time of the visit (May 1993), the seventh class of students was enrolled in the MnATCTC program. From FY 1990-1993, the MnATCTC program has received \$10.65 million in congressionally mandated funds to develop the program and to support students.

Students

Admission procedures and requirements

To be admitted to MnATCTC's program, candidates must be U.S. citizens and younger than 30 years of age. Candidates begin the admission process by completing a written application form. They must submit college transcripts demonstrating successful completion of a two- or four-year degree program. If an applicant's degree is not in aviation, he or she must also present a certificate indicating completion of at least one aviation course, obtained from either a fixed base operator or an accredited college or technical school. In addition, candidates must submit an FAA Class II medical certificate. In the final step, candidates must agree to a structured interview with representatives of the program. Interviews are conducted face-to-face if possible, but can be conducted by telephone if need be. The interview is used to assess the applicants' communication skills, level of maturity, and ability to pass a security check. It is also used to provide a realistic preview of the job of an ATCS, as well as what to expect while a student at MnATCTC.

Although some candidates take the OPM exam prior to applying to the program, the exam is not an admission criterion. Instead, the OPM exam is administered at the end of the first quarter (approximately 11 weeks into the program) to students who have not taken the exam previously. There are two reasons for this policy. First, OPM examinees can earn bonus points for their knowledge of aviation. By

administering the OPM exam at the midpoint of the program, students who do not have a strong aviation background (80% of MnATCTC's student body) increase their chances of earning bonus points on the exam. Second, the exam is administered early enough in the program so that the FAA can begin the security check for students who pass the OPM exam.

Before the initiative to adopt the computerized PTS test, Dr. Phillip Ackerman, a University of Minnesota consultant to MnATCTC, developed a written battery of tests to select students for MnATCTC's program. The tests were administered to students in the first seven classes as an experimental battery, but will be used to assist in making selection decisions for the eighth class. The battery consists of tests that measure reasoning, spatial ability, perceptual speed, and perceptual/psychomotor ability. A complete description of the test battery and validity results may be found in Ackerman (1992).

The mean and standard deviation of scores for MnATCTC's selection test are 50 and 10, respectively. Dr. Ackerman contends that the battery has not been administered to enough students to warrant the establishment of a formal cutoff score. However, his data indicate that most students who score 40 or above are successful in MnATCTC's program. Therefore, 40 has been established as a tentative cutoff. In making selection decisions for the upcoming eighth class, administrators will look for a minimum score of 40 on the battery; but they will consider admitting students who score in the upper 30s, but who have excellent academic credentials.

Tuition

Presently, tuition is covered by federal funds, so students incur no tuition costs. However, students must pay for books and materials and their own living expenses; there is no financial aid available for these expenses.

Recruiting programs

MnATCTC uses a variety of recruiting methods to inform candidates about its program. To recruit the first class, MnATCTC relied primarily on a local blitz advertising campaign. Since the first class, however,

MnATCTC's recruiting activities have focused on two other methods that have proved especially successful: the viewbook and personal referrals. The viewbook is a recruiting booklet provided to potential applicants. The viewbook describes air traffic control as a career, and the MnATCTC program, in particular. It also includes summaries of courses, a description of the Eden Prairie area, and an application form. Personal referrals are recommendations of the program made by career placement counselors, FAA employees, MnATCTC graduates, and MnATCTC faculty and staff. MnATCTC feels that referrals are the most effective recruiting method. For the October 1993 class, for example, almost half of the applications were obtained through referrals.

To increase minority enrollment, recruiters have advertised MnATCTC's program in minority publications. The *Black Collegian* has been particularly successful in generating applications. MnATCTC also uses its contacts with minority coalitions (e.g., Black, Hispanic, women) within the FAA. One of the goals of the minority coalitions is to educate fellow members of minority populations about careers in air traffic control. In that context, coalition members make presentations to school and community groups. During these presentations, MnATCTC's coalition contacts publicize the program at MnATCTC.

Student characteristics

Some of MnATCTC's incoming students have completed an associate's degree, but most hold bachelor's degrees. MnATCTC maintains detailed ethnic and gender data regarding the composition of its classes. Table 1 presents that information aggregated across the seven classes. As can be seen in Table 1, a majority of MnATCTC's students have been white and male. However, the table does not show the improvement MnATCTC has made in attracting minority and female students. For example, the first class was 96% white and 10% female, whereas the seventh class was 69% white and 53% female. MnATCTC has established an affirmative action goal of 60% total minority and female enrollment. To meet this goal, MnATCTC is willing to accept fewer than the optimal class size of 32.

Table 1

Gender and Ethnic Data for First Seven Classes in ATC Program at Minnesota Air Traffic Control Training Center

| Gender/ Ethnic Origin | Number | Percent of Total |
|--------------------------|--------|---------------------|
| Female | | |
| Asian | 3 | 1.4 |
| Black | 6 | 2.8 |
| Hispanic | 1 | 0.5 |
| Native American | 0 | 0.0 |
| White | 75 | 35.2 |
| Male | | |
| Asian | 8 | 3.8 |
| Black | 11 | 5.2 |
| Hispanic | 6 | 2.8 |
| Native American | 2 | 0.9 |
| White | 101 | 47.4 |

Table 2

Required Coursework for ATC Certificate at Minnesota Air Traffic Control Training Center

| Quarter | Course Code | Course Title |
|---------|-------------|-------------------------------------|
| First | ATCT100 | Introduction to Air Traffic Control |
| | ATCT112 | En Route Radar Fundamentals |
| | ATCT131 | Introduction to ATC-Radar Associate |
| Second | ATCT211 | Advanced Radar |
| | ATCT232 | Advanced Non-Radar |
| | ATCT251 | Advanced Radar/Radar Associate |

Program of Instruction

Curriculum

The ATC curriculum at MnATCTC, detailed in Table 2, is 22 weeks in duration and is divided into two 11-week quarters. The curriculum is very intense, requiring that students spend approximately eight hours per day in class or in lab. Although MnATCTC does not confer an academically recognized degree, students are awarded a certificate upon successful completion of the program.

MnATCTC is the only CTI-ATCS institution that provides instruction for the en route option only. Students learn to work both the en route radar control and the radar associate positions. However, the final training objective is that students be able to fill the radar associate position upon placement in an en route center. MnATCTC's agreement with the FAA outlined certain procedures that were to be used in curriculum development. Specifically, MnATCTC was to conduct an ATC job and cognitive analysis review, as well as an FAA training review. The agreement further specified the use of an Instructional Systems Design (ISD) approach to curriculum development and the inclusion of material contained in FAA Academy Instructional Program Guides (IPGs), En Route Phases I - III.

After conducting the required reviews, MnATCTC used the Vogler Curriculum-Pedagogy-Assessment (CPA) Model (Vogler, 1989) to develop their CTI-ATCS curriculum. The Vogler CPA Model is an ISD-type approach to curriculum development, which ensures that the knowledge and skills taught in the curriculum are directly traceable to specific job tasks. MnATCTC uses PEAKS, a curriculum development software package, which applies the Vogler CPA Model, to produce all their courses, lessons, and exams.

A general principle used by training developers at MnATCTC was to integrate theory and application as soon as possible in the learning experience. This principle was implemented by the following three-step format. First, theory and principles are introduced in a short lecture format. Second, students immediately begin to apply those principles by working on performance-based, written exercises in class

under the guidance of the instructor. Third, students move (after a short break) to MnATCTC's Radar Lab, where they apply the principles in laboratory exercises.

Instruction in team skills

Because their incoming students have college degrees, MnATCTC anticipates that its graduates will eventually move into FAA managerial positions. To help prepare students for management, as well as controller positions, MnATCTC has included team building exercises in their curriculum. These exercises are designed to demonstrate (a) the importance of the senses (i.e., speech, auditory, vision, and touch) in communication and task performance, and (b) the ways that people rely on each other to communicate and to complete tasks. The activities require students to work together in small groups to accomplish simple tasks. The tasks are simple physical activities that are unaffected by aptitude or athletic abilities. For example, one exercise requires that group members stand in a circle with hands joined. Two members join hands through a piece of surgical tubing. Keeping their hands clasped, the group must pass the tubing around the circle once. The exercise is timed so the group must work as quickly as possible.

In addition to the activities described above, students develop team building skills by working in study groups and with lab partners. The faculty determines lab partner assignments (i.e., radar controller and pseudo pilot operator), and assignments change each day. By changing partner assignments, students learn to work with people who have a variety of work styles. Team skills are particularly relevant in ATCT251 (Advanced Radar/Radar Associate) where students are organized into groups of four (i.e., radar controller, radar associate, pseudo pilot, and reliever) to complete complex exercises. Students are also exposed to Crew Resource Management (CRM) training, which has been successful in training team building skills for cockpit crews.

Faculty members are currently learning the Strength Deployment Inventory (SDI), an off-the-shelf training program designed to build team skills (Personal Strengths Publishing, 1990). In the first stage of SDI, individuals identify their own personal style (e.g.,

nurturing, assertive, analytical) through self- and peer-report questionnaires. Then, the individual and peer complete the questionnaire by assuming two life conditions—normal and stressful. After identifying their personal styles, individuals work in groups to complete exercises that require working with others who have similar or different personal styles. In theory, this teaches students to appreciate different personal styles and how to work with those differences. After faculty members become proficient with SDI, they intend to incorporate it into the current team building lessons.

Remediation policies

To remain in the program, students must maintain a "C" average or better in each class. Due to the intense schedule and the cumulative nature of the program, there is no opportunity for students to retake a class if they fail. Therefore, MnATCTC has developed a procedure to maximize the student's chances of success. Upon entering the program, each student is assigned a faculty advisor, who is typically assigned three advisees. The advisor receives input almost daily on the progress of his or her advisees through informal discussions with and voice/electronic messages to/from other faculty members. The advisor also meets with his or her advisees on a weekly basis to discuss their progress. If a student is performing poorly, the advisor may provide one or more remedial actions, such as providing tutorial services, referring the student to the Computer-Based Instruction (CBI) Lab, and arranging for tutoring from the course instructor. If a student continues to have academic trouble, the advisor may counsel the student about withdrawing from the program.

CBI Lab

The CBI Lab contains eight work stations, each equipped with an DOS-based personal computer with an 80386 processor networked to a single file server. MnATCTC's courseware was developed by its own computer programmer, and can be categorized into four groups or phases. The classifications reflect the evolution of MnATCTC's program with a different goal underlying the lessons in each group. The CBI lessons developed in Phase I provide a crash course in

aviation for students who enter the program with no aviation background. These lessons concern phonetic alphabet and numbers, phonetic numbers and usage, weather, aircraft performance, and airspace. Phase II CBI lessons supplement ATC material taught in the classroom. These lessons are designed for student self-remediation and refresher training, and include topics such as airspace reclassification, maps, three-letter identifiers, non-radar homework problems, time and distance problems, and D-side keyboarding. Development of Phase III lessons is currently underway. These lessons are designed to serve as part-task trainers of specific skills, such as a vectoring exercise wherein the student vectors aircraft through a maze. These lessons are also expected to serve particular functions within the curriculum, such as homework assignments. MnATCTC's fourth stage of lesson development will include the production of interactive videodisc programs, as well as faculty authorship of lessons.

CBI lessons are self-paced, with students able to enter and exit at any point in the program. Each lesson incorporates a post test consisting of multiple-choice items. These tests serve different purposes, depending on the phase during which they were developed. In keeping with the self-help philosophy, the post tests for Phases I and II provide prompts and immediate feedback. For example, students may review part of the lesson before answering a question. If they select an incorrect response, information is provided to explain why their response was incorrect. A correct response is rewarded with positive feedback. In contrast, the Phase III post tests (under development) do not provide assistance nor is feedback immediate; however students have an opportunity to review their answers. After reviewing their responses, students must indicate that they have completed the test, at which time the test is computer graded.

The computer system currently has some limited capabilities for tracking student use. For example, the system is capable of recording who uses which CBI lessons and which lessons are used. Stage III lessons are intended to be an integral part of the curriculum. Along with these lessons, MnATCTC personnel are writing software programs that will track CBI lesson use

more closely, including such information as which specific parts of the lesson are used, and scores on the post test.

Radar Lab

The Radar Lab simulates the radar section of an en route center. It is used in every course except ATCT100 (Introduction to Air Traffic Control). This lab employs the ATCoach® system and consists of 16 radar scopes, each of which is connected to a personal computer that serves as a pseudo pilot/pseudo facility position.

Each radar position is equipped with a headset, radar scope, a keyboard, a trackball, an area to hold flight progress strips, simulated telephone links to en route and terminal facilities, and an overhead projection map area. A pseudo pilot position has a headset, a keyboard, a mouse, and telephone links with the en route controller. When running a scenario, two students are commonly used to support a single radar position. One student acts as the radar controller while the other serves as the pseudo pilot/pseudo facilities operator. The controller and pseudo pilot communicate via headsets.

The radar positions can be set to operate independently of one another to train basic controller skills. As students advance, however, they must learn to coordinate with other controllers in the same center, as well as with controllers at other towers, terminal radar control (TRACON) facilities, en route centers, and flight service stations. When running coordinated scenarios, the radar positions can be configured to operate interdependently. For example, the simulated airspace (a portion of the Minneapolis En Route Center - ZMP, including Lincoln and Omaha, NE) may be divided into high and low positions. Thus, two student controllers working at adjacent scopes may be running a joint exercise, with one student controlling air traffic above a certain altitude, and another student controlling traffic below that altitude within the same geographic area.

Class size

MnATCTC administrators feel their optimal class size to be 32. In the past, MnATCTC has maintained close to the optimal number of students, with an average of 30 students across the seven classes.

Instructors and developers

MnATCTC employs five administrative staff persons and ten instructors. The staff includes a director, dean, recruiter, admissions officer, registrar, and an instructional services coordinator. The instructors are all former controllers, of whom about half have FAA backgrounds and about half, military backgrounds. The former FAA controllers left the FAA within three years prior to their employment with MnATCTC. The military controllers came immediately to MnATCTC upon discharge. Also, as a group, about half of the instructors have en route experience and about half have terminal experience. Most of them have training experience either in the military, at FAA facilities, or at the FAA Academy. One is a former public school teacher. The Minnesota Technical College System requires that all instructors be certified. Therefore, all of MnATCTC's instructors are certified at the technical-college level, and they must meet the system's continuing education requirements.

HAMPTON UNIVERSITY

Located in Hampton, VA, Hampton University (HU) is a privately endowed, coeducational, nonsectarian institution, and is a member of the Registry of Historically Black Colleges and Universities. HU's CTI-ATCS curriculum is subsumed under the university's Airway Science Program. The Airway Science program offers the Bachelor of Science (B.S.) degree with concentrations in Airway Science Administration, Airway Computer Science, Airway Electronic Systems, and Air Traffic Management. Recognized by the FAA since 1985, the Airway Science Program is an interdisciplinary curriculum developed by the FAA and the University Aviation Association.

In February 1990, E. L. Hamm and Associates contracted with the FAA through the Small Business Administration to develop a prototype ATC training program at HU. The result was the Terminal and En Route Airspace Management/Air Traffic Control (TEAM/ATC) program, a separate two-year curriculum leading to the B.S. degree. The first class began in June 1991. The TEAM/ATC program has received approximately \$3 million from the FAA to develop programs and to support students.

Students

Admission procedures and requirements

In addition to meeting general admission criteria at HU (e.g., high-school diploma or equivalency, college entrance exams), applicants to the CTI-ATCS program must meet further, more stringent standards. The minimum admission requirements for the CTI-ATCS program include:

- US citizenship;
- fluency in the English language, as assessed by an oral interview and a written essay;
- younger than 28 years of age at the time CTI-ATCS classes begin;
- two or more years of post-secondary education from an accredited junior/community college or university, with a minimum grade point average (GPA) of 2.7; and
- ability to meet OPM hiring requirements, including the medical evaluation, background security investigation, and the OPM written exam.

The recruiting material (described below) publicizes telephone numbers for HU's TEAM/ATC program. As a result, the first contact most applicants have with the program is by telephone. During this initial contact, applicants respond to a short, standardized questionnaire that functions as a preliminary screen. Questionnaire items employ a yes/no format and address the citizenship, English language ability, and age requirements for the CTI-ATCS program at HU. Callers are also asked whether they had ever been arrested or convicted of a crime, if they have any medical conditions they feel would hinder them as an air traffic controller, and whether they had completed two years of post-secondary education at an accredited college or university. Finally, callers are asked their college GPA and are told about the tuition waiver for CTI-ATCS courses. If callers provide the desired responses, their names and addresses are recorded, and application forms are mailed to them.

The application form asks for written responses to the telephone screening questions and for a short essay about why the applicant wants to be an air traffic controller. The primary purpose for the essay is to evaluate the applicant's command of written English. A secondary purpose is to examine the applicant's commitment to air traffic control as a career.

If applicants meet the minimum admission requirements, as determined by their responses on the written application, they are then asked to visit HU's campus for an in-depth interview with TEAM/ATC staff personnel (If a face-to-face interview is not feasible, the interview is conducted via telephone). The interview continues the process of evaluating the applicant's verbal language skills and assessing his or her commitment to a career in air traffic control. In addition, the applicant's post-secondary education is discussed in detail during the interview. The purpose of this discussion is to determine either that applicants have already completed HU's prerequisites in general education (40 semester hours) and Airway Science-related (13 semester hours) courses, or that they can complete the prerequisite coursework required by the TEAM/ATC program.

The OPM exam is not a requirement for admission to HU's TEAM/ATC program. Instead, the exam is administered a few months prior to graduation. In agreement with MnATCTC, HU administrators feel that delaying the OPM exam until after coursework is completed increases their students' chances to earn bonus points. In addition, HU administrators pointed out that OPM scores for CTI-ATCS graduates are kept on file for three years. By administering the exam near the end of the program, test scores are valid for three years after graduation, as opposed to one year if administered as a selection device prior to enrollment.

HU is also investigating the use of three personality tests as admission criteria: the Myers-Briggs Type Indicator, the California Psychological Inventory, and the Employee Aptitude Survey. All students admitted to the TEAM/ATC program have taken these tests. HU plans to validate scores on these personality tests against teacher and student subjective evaluations, and, if possible, against FAA subjective evaluations of performance after they are hired. Because the personality tests are administered only to those individuals who are accepted into the program, results from this research only indicate how well these instruments can predict who will succeed.

There are two goals to the personality research program at HU. The first is to determine whether training in team skills, which is integrated throughout the two-year program, affects the personalities of the

students. This objective requires re-administration of the personality inventories immediately prior to graduation. A secondary goal is to compare the success and failure of different kinds of personalities in the ATC workplace. HU faculty plan to correlate scores on the personality tests with teacher and student evaluations starting in the summer term of 1993. The results cannot be used to validate the tests as selection instruments.

Tuition

HU waived tuition costs for the first two TEAM/ATC classes. Students must bear tuition costs for general education courses and for textbooks, but financial aid is available to defray such costs. If and when the program becomes an established course of study offered by the university, students will be expected to assume all tuition costs. It is anticipated that financial aid will continue to be available on a demonstrated need basis.

Recruiting programs

E. L. Hamm has developed an extensive recruitment program aimed at minorities and women. As summarized below, six different media have been used to recruit these target populations:

1. **Radio advertisement.** Radio advertisements were aired on seven stations in three market areas, mostly within the Hampton area. Stations were selected because of their high listener ratings among those from 18 to 34 years old and for their high number of minority listeners. Two telephone numbers were listed in the ads: one for HU and one for E. L. Hamm. Because of their locations in the Virginia Beach metropolitan area, providing these two phone numbers allowed interested persons to call toll free from anywhere in the Hampton listening area. Radio advertising has demonstrated itself to be the most effective medium used to recruit CTI-ATCS candidates: 52% of the first class and 56% of the second class were recruited through radio advertisement.

2. **Newspaper advertisement.** A nationwide newspaper advertising campaign was undertaken. Advertisements were placed in publications with large circulations (e.g., *Atlanta Journal*, *Boston Globe*, *Los Angeles Times*), as well as in smaller newspapers with high minority

readership (e.g., *Chicago Defender*, *Virginian Pilot*, *New York Voice*). Newspaper advertising was much less successful than radio and was not used to recruit students for the second class.

3. **Campus visits.** Campus recruitment visits focused on community colleges with high minority enrollment. One HU ATC instructor and one E. L. Hamm employee visited community colleges in Maryland, Virginia, and North Carolina where they discussed the curriculum and distributed brochures and applications to students. These visits were expensive and labor intensive, and they resulted in no student interest in the CTI-ATCS program. As a result, campus visits were not used to recruit for the second class.

4. **Trade journal publications and advertisement.** HU staff wrote articles for or advertised in trade journals, such as *Virginia Aviation Newsletter*, *99 News*, *University Aviation Association*, and *ATCA*. Although used to recruit students for both of the first two classes, these efforts were of limited success.

5. **Direct mail advertisement.** Direct mail advertising was targeted at 472 colleges and 36 U.S. Navy educational counselors nationwide. These counselors were sent informational letters that introduced the CTI-ATCS program, provided a brief summary of the application requirements, and asked counselors to make the information available to students. The letter requested that interested students contact HU's recruitment representatives for additional information. Less than 2% of these letters resulted in requests for information about HU's CTI-ATCS program. A second direct mail campaign was aimed at community college career placement personnel. A poster and nine brochures accompanied this letter. Telephone response from this second campaign was better than the response from the initial effort; however, HU received no applications.

6. **Miscellaneous publicity.** Miscellaneous publicity included announcement letters mailed to news departments of local radio and television stations. These announcements led to two television interviews on local news and talk shows. Also, a marketing brochure was developed and distributed on college campuses, at Army installations, and at athletic events. Finally, instructors in HU's Airway Science Program publicized the CTI-ATCS program to students already enrolled at HU. These miscellaneous efforts, especially the outreach to

HU students, were quite successful. Of the first class, 22% were already attending HU, and 22% learned of the CTI-ATCS program through other miscellaneous methods. Of the second class, 33% were already attending HU, and 11% learned of the program through other methods that fall into the miscellaneous category.

Student characteristics

Students normally join the CTI-ATCS program after completing two years of general college education requirements at HU or some other accredited institution. HU and E. L. Hamm maintain detailed race and gender data regarding the composition of their CTI-ATCS classes. Table 3 presents that information for the two classes currently enrolled at HU. The two classes indicate a trend towards increasing diversity: Approximately 61.1% of the first (senior) class are either black or female, whereas 83.3% of the second (junior) class are in either one of those demographic groups. Particularly large gains in recruiting black females have been made in the junior class.

Program of Instruction

Curriculum

The two-year CTI-ATCS program at HU is designed to be taken after completion of two years of college coursework. It is actually six semesters in duration, which includes two summer sessions. The program grants the B.S. degree upon successful completion of the coursework.

The HU program provides instruction on both the terminal and en route options; however, the focus is on terminal operations. Students learn to work the flight data, ground control, and local control tower positions; the terminal radar position; and the en route data and radar positions. By the end of the program, students should be able to handle 85 aircraft per hour at the tower position, maintain an arrival rate of 55 aircraft per hour at the terminal radar position, and handle 45 aircraft per hour at the en route position. The curriculum focuses on the teamwork aspect of air traffic control, specifically coordination among ATCSs and between the ATCS and pilot. It also

Table 3

Gender and Ethnic Data for the Two Classes Currently Enrolled in Terminal and En Route Airspace Management/Air Traffic Control (TEAM/ATC) Program at Hampton University

| Class | Gender | Race | Number | Percent of Total |
|--------|--------|-------|--------|------------------|
| Senior | Female | Black | 5 | 27.8 |
| | | White | 1 | 5.5 |
| | Male | Black | 5 | 27.8 |
| | | White | 7 | 38.9 |
| Junior | Female | Black | 9 | 50.0 |
| | | White | 2 | 11.1 |
| | Male | Black | 4 | 22.2 |
| | | White | 3 | 16.7 |

includes courses in aviation theory, safety, and management. Table 4 presents HU's CTI-ATCS curriculum.

Under contract with the FAA, E. L. Hamm conducted an ATC job and cognitive analysis review, as well as an FAA training review. The contract specified the use of an

ISD approach to curriculum development and the inclusion of material contained in FAA Academy IPGs Phases I - IV for the terminal option and Phases I - III for the en route option. Course development began during the summer of 1990 when a training development team was identified. The team consisted of a military ATCS, a civilian ATCS, a pilot, a computer programmer, and an industrial psychologist. The team visited several FAA tower, TRACON,

and en route facilities across the US as well as the FAA Academy. During these visits, the curriculum development team gathered information about the job functions of terminal and en route ATCSs. Material covered in the designated IPGs were obtained from the Academy.

As in MnATCTC's program, HU's program is explicitly designed to integrate theory and application as soon as possible in the learning experience. Due to the hands-on focus, the laboratory exercises drove the course development process; that is, lab exercises were designed first, and then course lectures were written to support the exercises. In keeping with this principle, classes were scheduled approximately one hour before the lab. In this way, the material covered in class would be immediately applied in laboratory exercises.

Table 4

Required Coursework for the B.S. in Terminal and En Route Airspace Management/Air Traffic Control (TEAM/ATC) at Hampton University

| Semester | Code | Course Title | Hours |
|-----------------|------------|--------------------------------|-------|
| First - 12 hrs | ATC301 | Tower Operations I | 4 |
| | ATC/CRM315 | Tower Lab I | 5 |
| | ATC321 | Aviation Theory I | 3 |
| Second - 12 hrs | ATC302 | Tower Operations II | 4 |
| | ATC/CRM316 | Tower Lab II | 5 |
| | ATC322 | Aviation Theory II | 3 |
| Third - 12 hrs | ATC401 | Terminal Operations I | 4 |
| | ATC/CRM415 | Terminal Lab I | 5 |
| | ATC421 | Aviation Safety | 3 |
| Fourth - 12 hrs | ATC402 | Terminal Operations II | 4 |
| | ATC/CRM416 | Terminal Lab II | 5 |
| | ATC422 | Aviation Management | 3 |
| Fifth - 12 hrs | ATC423 | Contemporary Aviation Projects | 3 |
| | ATC431 | En Route Operations | 4 |
| | ATC/CRM445 | En Route Lab | 5 |
| Sixth - 12 hrs | ATC432 | ATC Facility Applications | 3 |
| | ATC446 | ATC Facility Lab | 4 |
| | ATC/CRM499 | Combined ATC Operations | 5 |

Instruction in team and managerial skills

The curriculum incorporates an approach to human factors training that HU terms "Controller Crew Resource Management" (CCRM). Crew Resource Management (CRM) has been used with much success to train cooperation and team building skills for cockpit crews. HU's approach is to apply CRM principles to air traffic control. Two goals underlie the use of CCRM: (a) to teach interpersonal skills with the intent of helping students become better human interactors as employees, with other controllers, and with pilots; and (b) to determine the extent to which CRM model devised for cockpit crews applies to controllers.

The curriculum does not include a separate course for CCRM. Instead CCRM training is implemented through classroom instruction, case study simulations, and the teamwork required to complete laboratory exercises. CCRM principles are presented in classroom lectures. As part of the classroom instruction, students must enact and solve real-life problems which are caused by interpersonal conflicts. The situations may be strictly interpersonal (e.g., sexual harassment), or they may be of a technical nature with an underlying interpersonal problem (e.g., an near accident caused by lack of coordination among ATCSs). Students are grouped into two- or three-person teams for laboratory exercises from the beginning of their involvement in the TEAM/ATC program. For tower cab exercises, students on a team alternate among data, ground control, and local control positions. For TRACON exercises, team members rotate among radar controller, radar assistant, and pseudo pilot positions. Team composition is changed each semester. This allows students ample opportunity to learn to function within the dynamics that are unique to each team, but puts them in as many different team situations as are reasonable.

Another important aspect of HU's program is the development of administrative and managerial skills. HU feels that their graduates are likely to attain managerial positions by virtue of their college degree. To ensure that graduates have a firm foundation on which to build managerial expertise, HU's curriculum includes courses in aviation safety and management.

Remediation policies

Given that the curriculum requires students to take a large number of courses consecutively, there is no opportunity for students to retake a class if they fail. To be fair to students, a rather detailed policy toward remediation has been instituted. The policy stipulates that students receive remediation and be retested on lessons where they score below the passing cutoff of 70% correct. With the exception of final exams and end-of-course research papers, all coursework is subject to remediation—whether it be homework, a lab assignment, a midterm exam, or other assignment. If students perform poorly on material covered in homework and lab assignments, they receive additional instruction, but the grade is unaffected. In contrast, students can improve their grade on midterm exams and reports by retaking the exam or rewriting the report. Students are allowed a maximum of two retests. If students fail a midterm exam, for example, they receive remedial instruction and retake the exam. If students fail the retest, they receive remedial training again and are retested. If students pass the midterm on the first retake, their scores on the exam are defined as 70%, regardless of actual score. If students fail the second retake, their scores on the exam are recorded as their actual test score.

CBI Lab

The CBI lab contains 10 DOS® -based personal computers equipped with 80286 processors and a file server equipped with an 80386 processor. CBI lessons were developed by an E. L. Hamm computer programmer working in conjunction with the TEAM/ATC faculty. The lessons feature high resolution graphics and quite a bit of animation. The lessons do not incorporate sound, because sound would be disruptive in the open laboratory setting.

The lessons, which cover rote material such as aircraft recognition, are used primarily to reinforce material taught in the classroom. Lessons are designed to augment, not supplant, the instructor. Another function of the CBI lessons is to provide remediation when a student scores less than 70% on an assignment or exam. CBI lessons may also be assigned as home-

work. The computer system is capable of recording who uses which CBI lessons, how long the person works on each lesson, and posttest scores.

VFR Tower Lab

The VFR Tower Lab is used to train tower cab operations in ATC/CRM 315 (Tower Lab I), ATC/CRM 316 (Tower Lab II), and for the first half of ATC/CRM 446 (ATC Facility Lab). The lab contains a table top replication of a hypothetical airport called Hampton Airport. The airport comes complete with a control tower; hangars and other buildings; scale-model general aviation aircraft, jet aircraft, military aircraft, helicopters; and scale-model rescue and maintenance vehicles. Hampton Airport has two parallel runways and an intersecting runway crossing one of the parallel runways. There is also a grass runway. The airport is equipped with functional runway lighting which adds a measure of realism when students practice night operations. Each student pseudo pilot communicates with the tower cab on a five-channel transmit/receive mobile radio headset.

A representation of a tower cab stands on a riser behind and slightly away from the model airport. The simulated tower cab is large enough to accommodate three students and an instructor. The cab contains headsets, an operable light gun, a 24-hour clock, a weather data display, a wind indicator, slots for holding flight progress strips, BRITE radar, an Automatic Terminal Information Service line, and a telephone used for communications with a simulated en route center (Washington, DC). Members of a CCRM team usually rotate among flight data, ground control, and local control ATC positions, while members from another CCRM team serve as "pilots" of scale-model helicopters and fixed-wing aircraft, and "operators" of rescue and maintenance vehicles.

During the first half of ATC/CRM 446, the Tower Lab is used in conjunction with the Radar Lab to train joint tower and TRACON operations. One CCRM team acts as tower cab controllers, one team serves as TRACON controllers, and remaining CCRM teams act as pseudo pilots. After team members have rotated among controller positions for their facility (e.g., among tower cab positions), teams change facilities.

During ATC/CRM 446, students also apply the principles of BRITE radar that were learned in ATC 302 (Tower Operations II).

Radar Lab

The Radar Lab simulates the radar section of a TRACON facility and an en route center. It is used in ATC/CRM 415 and 416 (Terminal Lab I and II), Terminal Lab II, ATC 445 (En Route Operations), ATC/CRM 446 (ATC Facility Lab, and ATC/CRM 499 (Combined ATC Operations). The simulation system is ATCoach® and is described in detail earlier in the context of MnATCTC's program. The following description highlights the unique aspects of this system at HU.

At HU, the simulation hardware consists of four radar scopes, each of which is connected to a personal computer that serves as a pseudo pilot/pseudo facility position. When running a scenario, four students are assigned to each station, playing roles of radar controller, radar associate, pseudo pilot, and pseudo facilities operator. If necessary, one student can serve as both pseudo pilot and pseudo facilities operator. Two two-person CCRM teams may be used to run an exercise such that one team functions as the controller and associate, while the second team serves as pseudo pilot and pseudo facilities operator. A three-person CCRM team may run an exercise: one controller, one assistant controller, and one pseudo pilot/pseudo facilities operator.

As students advance, they learn to coordinate with other controllers in the same TRACON facility, as well as with en route controllers and/or tower cab controllers. When running coordinated scenarios, the four radar positions can be configured to operate interdependently. For example, the Hampton airspace may be divided into feeder and arrival positions. Thus, two student controllers working at adjacent scopes may be running a joint exercise. When practicing a joint TRACON/en route scenario, three scopes may be setup as a TRACON facility (i.e., feeder, arrival, and departure positions), with the remaining scope serving as an en route center.

During ATC 499 (Combined ATC Operations), the Radar Lab is used to train joint TRACON and en route operations. Depending on the size of the team,

members from one or two CCRM teams act as a TRACON facility while a similar configuration of teams serves as an en route center (i.e., controller, assistant, pseudo pilot, and pseudo facilities operator). After team members have rotated among controller positions for their facility (e.g., among TRACON positions), teams change facilities; that is, students who were working as a TRACON facility now work as an en route center, and vice versa. The teamwork approach is thought to facilitate the development of interpersonal skills among controllers within a facility, among controllers in different facilities, and between controllers and pilots.

In addition to the radar positions, the Radar Lab is equipped with a part-task trainer based on the Verbex sound board and supplied by the manufacturer as an option to the ATCoach[®] system. This option is a voice-activated system in which the voices of ATCSs and pilots are simulated via a voice generation/recognition system. The Verbex-based system is, in essence, a part-task trainer used to train fundamental TRACON and en route skills, such as vectoring and aircraft separation. It can be run by a student with little or no oversight from an instructor. There is no concern about students picking up bad habits because the system will not respond to improper phraseology, improper vectorings, and so on.

Although the Verbex-based system can recognize almost anyone's voice within 4-5 hours under calm conditions, the voice activation system is quite sensitive to stress-related and other changes in the user's voice. To bypass difficulties in recognizing particular voices, the system also recognizes commands entered from the keyboard. Typed commands, like verbal commands, must use proper phraseology. The system responds to a combination of verbal and typed commands and typed commands can be used to override verbal commands. For example, if the system cannot recognize students because they have a cold, the student can type, rather than talk, to the system. It is unclear whether Verbex is effective at all as a part-task trainer, much less used in this fashion where the mode of responding has been changed.

Class size

The first two TEAM/ATC classes at HU each comprised 18 students. With the current equipment and level of staffing, HU faculty feel that they could comfortably accommodate a maximum of 24 students. Twenty-four students also fits the two- to three-person CCRM team configuration currently used.

Instructors and developers

The TEAM/ATC faculty includes two full-time HU employees and five E. L. Hamm employees/consultants. In addition to teaching responsibilities, the HU employees also perform administrative functions for the CTI-ATCS program. One HU employee is a pilot by background, and the other has experience as a military air traffic controller. Both were instructors at HU in Airway Sciences before the CTI-ATCS program was initiated.

Each E. L. Hamm employee and consultant has over 20 years of ATC experience. Two are retired FAA ATCSs: one en route and one terminal operator. In addition to controlling traffic, the retired en route controller served as a facility trainer and has been retired for two years; the retired terminal operator assisted with on-the-job training and has been retired for eight years. The remaining three E. L. Hamm employees have military ATC experience. Two are prior Air Force air traffic controllers, and one controlled air traffic in the Navy. All three prior-military controllers worked in a tower/terminal radar/non-radar environment, and all were facility trainers. One of the prior Air Force air traffic controllers taught at the Air Force's ATC technical school for 10 years; the other is a former high school instructor.

COMMUNITY COLLEGE OF BEAVER COUNTY

The main campus of the Community College of Beaver County (CCBC) is located in Monaca, PA. CCBC's Aviation Sciences Center is located in a separate facility in Beaver Falls, PA and is about 15 miles from the main campus. The Aviation Sciences Center is adjacent to the Beaver County Airport,

which is approximately 30 miles northwest of the Greater Pittsburgh International Airport. The CCBC Center/Airport complex includes the Beaver County Control Tower, which is equipped, staffed, and operated by CCBC students and their instructor/supervisors.

CCBC offers four distinct two-year programs in Aviation Sciences: Professional Piloting, Aerospace Management, Avionics Technology, and Air Traffic Control. Inaugurated in 1976, the Air Traffic Control (ATC) program is a two-year program leading to the degree of Associate in Applied Science (A.A.S.). In 1982, CCBC began offering an ATC Co-op program in conjunction with the FAA Eastern Region. In August 1990, CCBC signed a letter of understanding with the FAA to join the FAA's CTI-ATCS program with a terminal option. As soon as the letter was signed, CCBC began placing their graduates at FAA Level III tower facilities. The program at CCBC does not currently receive FAA funds for developing programs or for supporting students.

Students

Admission procedures and requirements

Aside from a high school diploma or its equivalent, there are no additional requirements for admission to the ATC program. Students must take math and English proficiency exams developed by CCBC to assess their readiness for college level math and English courses. If they are deemed unprepared, they must take remedial courses, but they are not usually denied admission. Although not an admission requirement, students are encouraged to obtain an FAA Class I medical certificate prior to entering the ATC program. Until they obtain this medical certificate, students cannot enroll in PP 106 (Private Pilot) or PP 239 (Facility Rating I), which are second and third semester courses, respectively.

Practical considerations prevent CCBC from using the OPM test as a selection instrument. Most of CCBC's ATC students are recent high school graduates. In order to sit for the OPM exam, an individual must have three years of general experience, four years of college, or a combination of education and experience equaling three years of general experience. There

are exceptions to the above experience/education requirements, but the exceptions still require more experience and/or post secondary education than an 18 year old has had an opportunity to obtain.

Tuition

Tuition fees at CCBC can vary, depending on whether the student is a graduate of (a) a Beaver County high school sponsor of CCBC (\$3,556), (b) a non sponsoring in-state high school (\$7,652), or (c) an out-of-state high school (\$11,748). CCBC administrators estimate that the total cost of obtaining the A.A.S. in Air Traffic Control ranges from \$12,000 to \$16,000, including tuition, the cost of obtaining the private pilot certificate, books, fees, and living expenses. It should be noted that during the course of their studies, students are required to earn a Control Tower Operator (CTO) certificate and the Facility Rating oral and hands-on exam for the control tower at the Beaver County airport. These exams are administered at no cost to the student by FAA CTO examiners from the Greater Pittsburgh Airport Traffic Control Tower.

Recruiting programs

Recruiting for the CTI-ATCS program is incorporated into CCBC's overall recruiting program. For the most part, the ATC program relies on the strength of its reputation to recruit students. To encourage minority enrollment, CCBC has formed relationships with 87 organizations having ties to the minority community in the Pittsburgh area, such as the Urban League and the NAACP. CCBC sends speakers to meetings of these organizations to discuss educational opportunities at the college. In addition, CCBC conducts some specialized recruiting for its Aviation Science programs through national advertising in aviation-related magazines.

Although not highly touted, CCBC's participation in the FAA's Co-op program is an effective recruitment tool. Participation in the 12-month Co-op program is highly competitive and is not guaranteed. For a CCBC student to be eligible for selection into the FAA Co-op program, he or she must:

- have completed CCBC's A.A.S. program in Air Traffic Control,
- be enrolled in a four-year program at one of two local institutions (Geneva College or Robert Morris College) as a full-time student, and
- not have completed more than 90 semester or 120 quarter hours.

Three Eastern Region FAA facilities participate in the Co-op program: Greater Pittsburgh International Airport, Baltimore-Washington International Airport, and Philadelphia International Airport. Although in theory, students may be placed at any of the three facilities, CCBC students are placed only at Greater Pittsburgh International.

Student characteristics

While a majority of CCBC's ATC students hail from the local area, students from across the state of Pennsylvania and from 24 states also are attracted to the program. Most students enroll in the ATC program immediately upon graduation from high school. The second largest age cohort comprises students who graduated from high school two to four years previously. Many of this latter group of students are transferring general education credits to CCBC; others have prior military service.

CCBC does not regularly maintain detailed race and gender data. The most recent compilation of student demographics was performed to identify students who could meet graduation requirements in May, August, and December 1993. From the 67 students whose demographic grouping could be determined, the overwhelming majority were white males (57 or 85%). Other represented groups included 8 white females (12%), 1 black male (1.5%), and 1 black female (1.5%).

From the initiation of the CTI-ATCS program at CCBC to March 1993, 89 students have been recommended for direct hire by the FAA. Note that this number reflects individuals recommended by CCBC for hire, and does not reflect the total number of ATC graduates. To be eligible for this recommendation, students must be (a) near completion of their third semester, (b) close to obtaining their private pilot

certificates, and (c) rated as "promising" by the ATC faculty. Of the 89 graduates of this program recommended for hire, 32 have been actually hired by the FAA.

Program of Instruction

Curriculum

The ATC program at CCBC provides formal training on the terminal option only, but includes some instruction in both tower cab and TRACON operations. Students learn to operate the flight data, ground control, clearance delivery, and local control tower positions as well as the terminal radar position. The final objective of the program is to produce graduates who can control the level of air traffic expected to be encountered at a Level III terminal facility.

The ATC curriculum at CCBC was not developed using a systematic model such as ISD; rather, it has evolved over the 17 years of repeated tryouts and revisions. Except for the addition of two radar control courses, the curriculum has remained relatively unchanged from the courses offered before CCBC became part of the FAA's CTI-ATCS program. One exception is that CCBC added terminal radar to the curriculum after learning that their graduates would be required to perform radar operations as a part of performance verification (PV).

Table 5, which is adapted from the CCBC Aviation Handbook, presents the recommended course progression for ATC students. The ATC program can be divided into three broad areas as follows:

1. **General Education.** General education requirements are spread throughout the two year period, but are concentrated in the first semester. These general education courses are intended to produce well-rounded ATCSs with the background necessary to become ATC managers for the FAA.

2. **Private Pilot Certificate.** Although a private pilot certificate is not necessary to become a successful ATCS, the ATC faculty believes that it gives students a better understanding of air traffic control from a pilot's perspective. Two courses are required to earn the Private Pilot Certificate: PP 110 (Flight Theory) and PP 106 (Private Pilot). PP 110 prepares students for the FAA written exam for the Private Pilot Certificate, which is

the final exam for the course. PP 106 enables students to obtain the required flying hours necessary to earn the Private Pilot Certificate. The latter course is administered by fixed base operators (FBOs) associated with CCBC and located nearby: Beaver Aviation, Moore Aviation, and Stensin Aviation at the Beaver County Airport; Haski Aviation at the New Castle Airport; and Beaver Aviation at the Butler County Airport. Students are encouraged to use one of these FBOs to fulfill their flight requirements. Students who have a Private Pilot Certificate prior to enrollment in the ATC program may place out of these two courses.

3. **Terminal ATC Operations.** While earning general education requirements, students take prerequisite ATC courses, where they learn such basic principles as meteorology, aircraft recognition, and basic phraseol-

ogy. Procedures specific to tower cab and terminal radar operations are taught in separate courses, which run concurrently during the third and fourth semesters. The program has a strong emphasis on the practical application of ATC knowledge and skills. With PP 239 (Facility Rating I) and PP 247 (Approach Control I), both third semester courses, students begin to apply the knowledge learned in the classroom to control air traffic in the laboratory and in the Beaver County Control Tower, an FAA Level II VFR facility. The practical application of lecture material begins within the first week of the classes. Furthermore, practical exercises immediately follow lecture presentations. After attending a lecture on vectoring aircraft, for example, students complete vectoring exercises in the lab that afternoon or the next morning.

Table 5

Required Coursework for the A.A.S. in Air Traffic Control at the Community College of Beaver County

| Semester | Code | Course Title | Credit |
|-----------------------|-------|---|--------|
| First - 16/17 credits | PP110 | Flight Theory | 4 |
| | PP123 | Airman's Knowledge | 3 |
| | HE155 | English Composition | 3 |
| | MA155 | College Algebra | 3 |
| | MP161 | or | |
| | | Physical Science Social Science Elective | 4 3 |
| Second - 17 credits | PP106 | Private Pilot | 3 |
| | PP121 | Aviation Meteorology | 3 |
| | PP136 | Theory of Instrument Flight | 4 |
| | PP236 | Advanced ATC III | 4 |
| | HE156 | English Composition II | 3 |
| Third - 16 credits | PP239 | Facility Rating I | 6 |
| | PP247 | Approach Control I | 4 |
| | HL260 | Logic | 3 |
| | | Social Science Elective | 3 |
| Fourth - 16 credits | PP240 | Facility Rating II | 6 |
| | PP248 | Approach Control II | 4 |
| | BD150 | Introduction to Computers | 3 |
| | | General Education Elective | 3 |

CBI Lab

Although some lessons address advanced ATC procedures, the CBI lessons are used primarily to reinforce material taught in prerequisite ATC courses. The lab contains 12 personal computers equipped with 80386 processors. Each computer serves as a stand-alone device. Some of the commonly used lessons are stored on the hard drive of each computer; other lessons are available on diskette.

With the exception of an air traffic control application that utilizes the Beaver County airspace, the CBI lessons were provided by the FAA Academy. Included in the Academy-provided lessons are 156 lessons that can be grouped into four broad categories: (a) general information on FAA employee procedures (e.g., pay system, employee benefits, drug awareness), (b) introductory ATC materials (e.g., aircraft identification, weather, navigation),

(c) en route procedures and responsibilities, and (d) terminal controller responsibilities. Also, among the Academy-provided software are 87 lessons on operations at terminal facilities

The CBI lessons are not used as part of graded coursework; that is, lessons are not assigned as homework, posttest results are not counted as part of course grades, students cannot earn "extra credit" for completing CBI lessons, and so on. Students use CBI lessons to supplement classroom and laboratory instruction at their own discretion.

Facility Lab

The purpose of the Facility Lab is to train tower cab operations in PP 239 (Facility Rating I) and to transition from tower cab to radar operations in PP 240 (Facility Rating II). The lab contains a table-top reproduction of the Beaver County Airport, complete with a control tower, hangars, and scale-model airplanes, helicopters, and rescue vehicles. Behind one corner of the model airport is a representation of a small section of the interior of Beaver County's terminal, including an operable beacon light, a 24-hour clock, an altimeter, an electronic weather vane, slots for holding flight progress strips, and a telephone used for simulated communications with the Greater Pittsburgh tower. The table top model replicates Beaver

County Airport's single 4,500 foot runway, but the model can be altered to accommodate an additional intersecting or parallel runway.

In PP 239 (Facility Rating I), laboratory instruction begins with students moving toy airplanes and helicopters in response to air traffic control commands issued by fellow students. To transition between tower and radar operations, the Facility Lab is equipped with a "master" computer, a transparency projector, a large viewing screen, three "ghost pilot" computers, and headsets for both local control and ghost pilots. The master computer, which is operated by an instructor, interfaces with the transparency projector to project Beaver County's airspace on a large screen. The master computer controls everything that is projected onto the screen, including the size of the airspace, the number and type of aircraft that appear in the airspace, the direction from which the aircraft enter the airspace, weather conditions, and the presence or absence of a data box beside each aircraft.

In PP 240 (Facility Rating II), students are beyond using the table top replication. In this class, they primarily use the Facility Lab's computer capabilities. Students rotate among flight data, local control, ghost pilot, and Pittsburgh tower positions. Because the computer capabilities replicate a radar environment, the ground control position cannot be simulated.

Radar Lab

The Radar Lab simulates the radar section of a TRACON facility and is used in PP 247 and 248 (Approach Control I and II). The system was developed specifically for CCBC by Wesson at a cost of approximately \$150,000 and has been in place since the summer of 1992. The hardware consists of four radar positions and eight ghost pilot positions. It is functionally similar to the ATCoach system described for MnATCTC and HU. The present section highlights the unique features of the system at CCBC.

The radar positions are each equipped with a headset, radar scope, a keyboard, a trackball, an area to hold flight progress strips, and an overhead projection area. A single radar position is connected to and can control up to four simulated aircraft. Depending on

the class size, one or two students serve as ghost pilots for one radar position. With practice, ghost pilots can "fly" several aircraft at a time.

The software simulates a portion of the Greater Pittsburgh airspace. In all, 22 exercises are available for PP 247 (Approach Control I), and 20 exercises are available for PP 248 (Approach Control II). In PP 247, as students first learn radar control, the radar positions can be set to operate independently of one another; that is, a single exercise can be run at all four radar positions simultaneously, or a different exercise can be run at each radar position. In PP 248, students learn to coordinate with other controllers in the same TRACON facility as well as with pilots and en route controllers. In this case, the four radar positions can be set to operate interdependently. For example, the Greater Pittsburgh airspace can be divided into Approach North, Departure North, Departure South, and Approach South with each scope displaying its appropriate sector.

Beaver County Control Tower

CCBC is the only community college in the nation that staffs and operates a functioning air traffic control tower. For the most part, air traffic is controlled by students under the close supervision of their instructors who are experienced controllers. The control tower is used for on-the-job training (OJT) during the third and fourth semesters in PP 239 and PP 240 (Facility Rating I and II). The Beaver County Airport is a general aviation airport only, and as a result, students do not have an opportunity to control commercial jet aircraft. However, students do acquire hands-on experience controlling a variety of general aviation aircraft, including helicopters.

Before working in the tower, students must have complete PP 326 (Advanced ATC III) and passed the CTO written exam. Students begin OJT in Facility Rating I by working in the flight data and ground control positions. In PP 240 (Facility Rating II), students work in the local control position. OJT culminates with a student's earning the facility rating for Beaver Tower.

Class size

CCBC's ATC classes are limited to 24 students. For lab courses (PP 239, 240, 247, and 248), classes of 24 are divided in half; that is, half of the class meet for two hours on Mondays and Wednesdays, while the other half meet for two hours of lab work on Tuesdays and Thursdays. No classes meet on Fridays.

Instructors and developers

CCBC's ATC program employs six instructors. These instructors work full-time (i.e., 37 hours per week) in the Beaver County control tower and serve as part-time instructors at CCBC. Three instructors are retired FAA ATCSs: Two have ATC experience at non-FAA control towers, and one is a former FAA employee.

UNIVERSITY OF NORTH DAKOTA

The University of North Dakota (UND) is a state supported institution located in Grand Forks, ND. UND's Center for Aerospace Sciences (CAS) is the second largest college at the university and offers training in a variety of areas, ranging from flight training to atmospheric study. Subsumed under CAS is the Department of Aviation, which offers four distinct four-year curricula leading to the B.S. degree: Aviation Administration, Airport Administration, Aeronautical Studies, and Airway Science.

In February 1991, UND signed a letter of understanding with the FAA to become part of the CTI-ATCS program. This program is incorporated in UND's CAS as Air Traffic Control Operations (ATC Ops), one of six concentrations in the Airway Science curriculum. ATC Ops has not received FAA funding directly for program development or student support, but the Airway Sciences Program has been the recipient of \$24.7 million in grants during the period FY 1982-1993.

Students

Admission procedures and requirements

Incoming students must meet the general university admission criteria, which includes a high school diploma or equivalency and a minimum score of 21 on the American College Test (ACT). In addition,

applicants to the ATC Ops program must meet further, more stringent standards. Minimum admission requirements for the program are:

- completion of freshman year (24 hours) with a minimum GPA of 2.5 on a 4.0 scale;
- completion of Avit 102 (Private Pilot), or an FAA-certified Private Pilot Certificate;
- enrolled in/completion of Avit 303 (Introduction to ATC) with a minimum grade of C;
- FAA Class II Medical Exam - ATC Type;
- US citizenship;
- ability to graduate prior to age 30; and
- capability of graduating in five semesters after starting the CTI-ATCS program.

Students begin the admission process by completing a written application. In addition to background data (e.g., name, address), the application requests information regarding the applicant's education. College transcripts, Private Pilot Certificate, and Class II Medical Certificate must be submitted with the written application. The completed application is then used to determine whether the candidate meets the minimum admission requirements for the CTI-ATCS program.

Students who meet the minimum admission requirements must complete a battery of three standardized tests. One of these is the Raven Matrices, which is an aptitude test designed to measure analytic ability and visual processing and has been termed a "nonverbal intelligence test." The students also take two better known psychological instruments: (a) the Minnesota Multiphasic Personality Inventory (MMPI), a clinical assessment instrument; and (b) the Keirsey Temperament Sorter, a temperament inventory. The aptitude, personality, and temperament measures are administered, scored, and interpreted by a faculty member from the UND Department of Psychology.

In addition to the standardized tests, prospective students must submit to a selection interview. The selection interview is conducted by a three-member panel that includes the ATC Ops program director, an instructor, and a representative of CAS Student Services. The structured interview consists of six questions that are intended to assess the candidate's motivation for a career in air traffic control. Each interviewer provides a numerical rating for the

candidate's response to each question. Upon completion of the interview, the interviewers compare their ratings and attempt to reach a consensus regarding the candidate's potential for success as an air traffic controller.

In making selection decisions, the results of the assessment measures and the structured interview are reviewed collectively. A score of 20 on Raven Matrices, corresponding to a percentile score of 85, is used as a tentative cutoff score for the program. This cutoff is tentative in that administrators will consider admitting students who score lower than 20 if they have excellent academic credentials and score well on the interview. Results of the MMPI and the Keirsey Temperament Sorter are used primarily to corroborate the results of the selection interview; no strict selection criteria have been adopted for these instruments. Although all four measures are used to make a selection decision, the interview is weighted more heavily than the others.

As in the previous programs, the OPM exam is not a requirement for admission to UND's CTI-ATCS program. Instead, the exam is administered during the student's final semester. UND agrees that this policy increases the students' chances of earning bonus points and lengthens the period of time that the OPM test scores are valid.

Tuition

Students must assume all tuition and other costs associated with obtaining their degree. Total cost (i.e., tuition and fees, room and board, and books and supplies) for one year at UND ranges from \$5,166 for residents of North Dakota to \$8,274 for non-residents. In addition to these costs, CTI-ATCS students must bear the cost of obtaining a private pilot certificate, which is approximately \$5,000. Financial aid is available on a demonstrated need basis.

Recruiting programs

UND's recruitment effort for the ATC Ops program focuses on women and minorities. Much of the early recruitment for the program targeted students currently enrolled at UND, specifically those enrolled in courses provided by CAS and the Department of Aviation. These efforts, which are on-going, consist

primarily of publicizing the program through UND student support groups such as the Women's Center, Veteran Services, International Studies Support Center, Enrollment Services, and the Dean of Students.

Because Native Americans are the largest ethnic minority in North Dakota, UND's recruitment efforts have been concentrated on this particular population. Initial contact began with ATC Ops faculty making recruiting visits to the five tribal community colleges in North Dakota: Fort Berthold Community College, Little Hoop Community College, Turtle Mountain Community College, Standing Rock College, and United Tribes Technical College. These initial visits did not result in many applications to the UND program. However, the faculty learned that traditional recruiting approaches are not effective with the Native American community and developed programs to address some of the lessons they learned.

One problem encountered in recruiting Native Americans is that many do not want to leave the reservation. To address this problem, UND intends to establish a distance learning satellite link with North Dakota's five tribal colleges beginning with the fall semester of 1994. The distance learning program is designed to facilitate transition from the reservation to UND, and to the outside world. UND will provide, via satellite, one aviation course for each semester of the freshman and sophomore years. During the summer between their freshman and sophomore years, students will attend UND to earn their private pilot certificate. Students will then transfer to UND for their junior and senior years. The distance learning program is targeted toward students who may be interested in a variety of aviation-related careers, not just air traffic control. Nevertheless, Airway Science faculty at UND anticipate that the distance learning program will result in increased Native American enrollment in the ATC Ops program.

A second outreach program is aimed at Native Americans in junior high and high school. UND administrators specify two reasons for reaching out to pre-teens and teens. One reason concerns the reluctance to leave the reservation described above. It is hoped that some junior high students will become interested enough in an aviation career to consider leaving the reservation. If so, emotional separation

from the reservation can begin early and continue slowly over several years, thereby increasing the individual's probability of succeeding in a career away from the reservation. A second reason for reaching out toward pre-teens and teens concerns alcoholism. Alcoholism is such a pervasive problem on reservations that many potential ATC candidates are ineligible for FAA employment due to their inability to pass the security evaluation. UND hopes to develop enough interest in aviation among young people that they will be motivated to remain drug and alcohol free.

Student characteristics

Table 6 presents the gender and ethnic breakdown for all three classes currently enrolled in UND's ATC Ops program. Early on, UND established recruiting goals of 10, 20, 35, and 50% diversity for the first through the fourth ATC Ops classes, respectively. Note that UND exactly met its diversity goal of 10% women and minorities for the first class (1993). UND more than met its 20% diversity goal for the second class (1994) with 40% of the class consisting of women and minorities. The third class (1995), which includes 31.2% women and minorities, fell slightly short of the goal of 35%.

Program of Instruction

Curriculum

The ATC Ops program at UND is 125 semester hours in duration and spans five semesters (including one summer session). The program provides instruction on the terminal option with a focus on TRACON operations. Students learn to operate the terminal radar and radar associate positions. The final training objective is to produce graduates who are able to "...utilize ATC skills to control airplanes in a terminal environment in accordance with performance verification requirements set by the FAA" (personal communication, Bill Droke, July 18, 1993).

Because the ATC Ops program is a concentration within the Airway Sciences program, students must fulfill 86 semester hours of Airway Science Core Curriculum course requirements (Table 7 presents an abbreviated version of the core curriculum.) One of these core courses is Avit 102 (Introduction to Aviation), wherein students can earn the Private Pilot

Table 6

Gender and Ethnic Data for Three Classes
Currently Enrolled in ATC Ops Program at the
University of North Dakota

| Graduating Class of | Gender | Race | Number | Percent of Class |
|------------------------|--------|-------|--------|---------------------|
| May 1993 | Female | White | 1 | 10.0 |
| | Male | White | 9 | 90.0 |
| May 1994 | Female | White | 2 | 20.0 |
| | Male | White | 6 | 60.0 |
| | | Black | 2 | 20.0 |
| May 1995 | Female | White | 3 | 18.8 |
| | Male | White | 11 | 68.8 |
| | | Black | 2 | 12.5 |

Table 7

Core Curriculum for Airway Science Program at the University of
North Dakota

| Hours | Area | Sample Courses |
|-------|-----------------------------|--|
| 30 | General Studies | Composition I American Government Humanities Electives |
| 23 | Math, Science, & Technology | College Algebra Introductory College Physics Meteorology |
| 15 | Aviation | Introduction to Aviation Introduction to Air Traffic Control Aerospace Legislation |
| 9 | Computer Science | Computer Programming I |
| 9 | Management | Principles of Management |

Certificate required for admission to the ATC Ops program. Like CCBC, UND program administrators feel that this instruction is valuable in understanding air traffic control from a pilot's perspective. Students who have an FAA-certified Private Pilot Certificate prior to enrollment in the program may place out of this course.

As specified in their agreement with the FAA, UND developed their ATC Ops curriculum from an analysis of the controller's job. Working with task data provided by FAA, UND course developers identified and documented the specific tasks to be trained and the level to which those tasks should be trained (i.e., informational, cognitive, or performance). They then cross-referenced these tasks to the course in which they are taught. Documentation is available for Avit 303 (Introduction to ATC), a prerequisite for admission into the CTI-ATCS program, and for the ATC Operations courses (i.e., Avit 306, 310, 401, 404, 406, and 412).

As shown in Table 8, the 39 semester hours of ATC courses can be divided into three broad areas: ATC operations courses, aviation related courses, and other required courses. As mentioned previously, UND's ATC Ops program focuses on TRACON operations;

just one course addresses tower cab operations. In Avit 310 (ATC Tower Operations), students are exposed to the principles of tower cab operations, but they receive no laboratory training on this subject.

As in MnATCTC's and HU's programs, UND's curriculum is designed to integrate theory and application early on in the learning experience. With the exception of Avit 310 (ATC Tower Operations), which is described above, all ATC courses are scheduled for two-hour classes. Theory and principles are presented in the first hour; students then apply those principles in laboratory exercises in the second hour ATC Lab. Avit 412 (Advanced ATC Radar/Nonradar III) is a comprehensive, lab-oriented course that is exclusively devoted to application. Students must demonstrate comprehensive ATC abilities in a UND's simulation system described below. These abilities include coordinating with other controllers in the same TRACON facility, as well as with controllers at terminal facilities and en route centers.

An important aspect of UND's ATC Ops program is the development of administrative and managerial skills. UND expects that their graduates will be considered for managerial positions by virtue of their college degree. To ensure that graduates have a firm

Table 8

Required Coursework for the B.S. in Airway Science (ATC Ops Concentration) at the University of North Dakota

| Substantive Area | Code | Course Title | Hours |
|------------------|----------|---------------------------------------|-------|
| ATC Operations | Avit 306 | ATC Radar Operations I | 4 |
| | Avit 310 | ATC Tower Operations | 2 |
| | Avit 401 | Advanced ATC Radar Operations II | 4 |
| | Avit 404 | Advanced ATC Nonradar I | 4 |
| | Avit 406 | Advanced ATC Nonradar II | 4 |
| | Avit 412 | Advanced ATC Radar/Nonradar III | 4 |
| Aviation Related | Avit 250 | Human Factors | 2 |
| | Avit 402 | Airport Planning and Administration | 5 |
| Other Required | Mgmt 310 | Organizational Behavior | 3 |
| | Comm 210 | Intro. to Interpersonal Communication | 3 |
| | Psy 360 | Intro. to Personality | 3 |
| | PSi 437 | Administrative Processes | 3 |

foundation on which to build managerial expertise, UND's curriculum includes courses to help students understand human behavior at the individual level as well as at higher organizational levels. Managerial courses are included in both the core curriculum and the ATC Ops program.

ATC Lab

The ATC Lab at UND simulates the radar section of a TRACON facility. It can also be used to simulate an en route center, but is not used as such because the curriculum does not prepare students for placement in en route centers. It is used in all ATC courses, with the exception of ATC Tower Operations. The simulation system is Virtual Controller, which was developed at UND.

Virtual Controller's software is divided into three subsystems, which serve unique functions in building and monitoring laboratory exercises. The subsystems are summarized below:

1. The Profile Editor is an aircraft database and includes U.S. and international civilian and military airplanes and helicopters. Performance capabilities of each aircraft (e.g., speed, climb and descent rate, turn profile) and call signs are included. The database currently contains data for 360 types of aircraft, but more can be added.

2. The Aircraft Builder is used to create laboratory exercises by retrieving data from the Profile Editor, by specifying weather conditions, by designating the airspace, and so on. UND uses the same airspace that is used for training at the FAA Academy: Aero Center (ZAE). However, Aircraft Builder is capable of depicting a hypothetical airspace or any existing airspace.

3. The Training Management subsystem maintains a database of the exercises completed by each student and provides feedback on exercise performance. Feedback consists of pointing out the error and providing a reference in the FAA Handbook (Order 7110.65) that identifies the proper response. Feedback may be presented immediately as the scenario progresses or as a final scenario grade. The Training Management subsystem can output feedback to the screen, to a printer, or both. Instructors may pause a scenario, replay portions of a scenario, or replay all of a scenario when discussing a student's performance.

The hardware consists of 10 radar scopes, each of which is connected to a personal computer that serves as a pseudo pilot/pseudo facility position. Each radar position includes a headset, radar scope, a keyboard, a trackball, an area to hold flight progress strips, simulated telephone links to en route and terminal facilities, and a map display provided by an overhead projection. In addition to controlling simulated air traffic, the trackball is used in a menu-driven application to load exercises. The screen can be set to project in monochrome or in color. Color projections are in keeping with the new radar system, the Advanced Automation System (AAS) being developed for the FAA. The overhead projection area contains a map of the Aeronautical Center airspace and radio frequencies for terminal facilities and en route centers used in the exercises.

When running a scenario, a single radar position may be supported by as many as four students assuming the roles of radar controller, assistant controller, pseudo pilot, and pseudo facilities operator. More commonly, a radar position is staffed by two students who assume the roles of radar controller and pseudo pilot/pseudo facilities operator. While engaged in the simulation, students communicate via headsets. Virtual Controller has voice activation capabilities eliminating the need for a pseudo pilot, although someone is still be needed to serve as a pseudo facilities operator.

As is true for ATCoach®, the workstations can be configured to run independently or in a coordinated scenario. The former is more appropriate for students who are first learning radar control, whereas the latter is useful in learning to coordinate with other controllers in the same TRACON facility, as well as with controllers at terminal facilities and en route centers. For example, the simulated Aeronautical Center airspace may be divided into arrival and departure sectors. Thus, two student controllers working at adjacent scopes may be running a joint exercise, with one student controlling arrival air traffic and another student controlling departure traffic.

CBI Lab

ATC CBI lessons are run on Virtual Controller. Fifty CBI lessons are available for first- and second-semester students. These lessons, developed for the Minnesota Air National Guard, teach ATC basics. Because the material is basic and somewhat repetitive, the lessons employ animation to hold the student's interest. The lessons are self-paced, and feedback is immediate. The student may review previously presented material by reversing through the program one screen at a time. Also, a student may exit the lesson at any time. Finally, embedded questions are included in the lessons so students can test themselves.

The CBI lessons have not been used as part of graded coursework in the past. Instead, students primarily used CBI lessons to supplement classroom instruction at their own discretion. Beginning with the fall semester of 1993, however, ATC Ops assigns CBI lessons as homework. A written, knowledge-based exam is administered to ensure that students complete the lessons and to assess their understanding of the material covered in the lesson.

Class size

In the past, UND's class size has been about 10 students. With the current level of staffing, program administrators feel that 10 students are a comfortable load. Although UND has enough radar simulators to accommodate 25 to 30 students, more instructors are needed to support a class of that magnitude.

Instructors and developers

UND's ATC Ops program employs four instructors. One of the instructors also serves as the director of the ATC Ops program. Two instructors (including the director) are former Air Force controllers. The other two instructors are recently retired FAA ATCSs, with one having en route and the other, terminal experience. All four instructors have prior teaching experience: The former Air Force controllers have extensive experience as OJT instructors in the military, and the two retired FAA controllers taught at the FAA Academy.

UNIVERSITY OF ALASKA, ANCHORAGE

The CTI-ATCS program at the University of Alaska (UAA) evolved from an ATC program started in 1971 at the Anchorage Community College. When the community college merged with UAA in 1988, the ATC program continued within the university's College of Career and Vocational Education. Before being incorporated into the CTI-ATCS program, the ATC program in Anchorage was designed to prepare students to pass the OPM written test and to attend the FAA Academy. As evidence of the older program's effectiveness, program administrators often cite the fact that, of their graduates who were accepted at the Academy, well over 90% successfully completed the screen.

The ATC at UAA program was accepted as a CTI-ATCS institution in November 1991 for both terminal and en route options. That same year UAA was also approved as a CTI program in electronics technology, and is the only institution having both types of CTI programs. In March 1992, UAA's approval as an Airway Sciences institution was extended. In addition to Air Traffic Control and Aviation Electronics Technology, UAA offers three other aviation-related programs of study: Aviation Administration, Aviation Maintenance Technology, and Professional Piloting. These latter programs are not yet part of the approved Airway Science curricula. Aviation Maintenance Technology has been submitted for approval, but has not received final endorsement.

Whereas the ATC program has not been a direct recipient of FAA funds, the Airway Sciences program has received \$6.9 million in funds from FY 1982-1993. In addition, UAA recently received a \$10.5 million dollar grant for capital improvements to the program. Some of these funds will be used to build a new training facility for ATC and for other improvements to the Airway Science program.

The Alaska Region of the FAA actively participates in the UAA program in Aviation Sciences. Representatives from the region sit on a board of advisors who provide formal guidance and valuable subject matter expertise to the ATC program at UAA. In return for their participation, the region hopes to gain from

UAA's CTI-ATCS program a source of highly trained ATCSs who have a extensive knowledge of Alaskan airspace and are committed to staying in the region.

Students

Admission requirements and procedures

UAA maintains an "open enrollment" policy, requiring only that students (a) be 18 years or older, (b) have a high school or general equivalency degree, and (c) participate in UAA's assessment and advisement process. Students interested in the ATC program are advised of the FAA requirements for employment, including the attainment of a Class II medical certificate and the maximum age limitation (30 years) for employment as an ATCS.

The OPM test is not a requirement for admission to the program. In fact, students have been advised to delay taking the test until after completing the program to increase their chances of attaining a high score. However, it has recently become clear that students must take the OPM test well before graduation to avoid delays in hiring. Consequently, the UAA advisory committee has recommended that the OPM test be taken at the end of the first year or the beginning of the second year of study.

Tuition

Tuition is calculated at \$64 per credit hour, totaling \$3,907 as a maximum total cost for the 61 credit hours required by the program. Additional fees include \$280 for eight hours of simulator training and \$220 to cover aircraft operation costs in the AT 144 (ATC Airborne Lab).

Recruiting

Much of the recruiting at UAA is conducted unofficially by the director of the ATC program. He talks to many program candidates through his active involvement in the Civil Air Patrol and other aviation activities throughout the state. Official recruiting activities are conducted through UAA's Enrollment Services Office, which recruits students statewide for all UAA programs. This office sets up booths at Alaska College and Career Fairs held in the larger cities of Anchorage, Fairbanks, Juneau, and Ketchikan. For

smaller villages, representatives of Enrollment Services speak on request at regional fairs and at local high schools.

To promote recruitment of underrepresented students, the UAA offers one full scholarship per year in the ATC program to be awarded to either a female or a minority group member. In addition, Enrollment Services maintains separate special offices for recruiting and retaining both Native and African American students. The Native American office administers a program to help students make the transition from village life to life in Anchorage and at the university. This program is viewed as helping to keep Native American students in school.

Student characteristics

With its urban mission and commuter-campus environment, UAA attracts older students with an average age of about 28. Because of FAA age requirements, students in the ATC program are a bit younger (about 25-26). Detailed demographics of ATC classes prior to the establishment of the CTI-ATCS program are not available. However, the Alaska Region tracked 176 graduates of UAA who have some record in the FAA's Consolidated Personnel Management Information System (CPMIS). Of those having a CPMIS record, 95 (54.0%) worked for the FAA for some period of time or are still with the FAA, and 45 (25.6%) are women. Of the 45 women hired by the FAA, 17 (37.8%) are still with the agency.

The first class of 20 CTI-ATCS students graduated this spring. In this class of 20, 6 already were employed by the FAA and 2 were not seeking FAA employment. Of the remaining 12 students who were actively seeking FAA employment, there were 9 white males, 2 white females, and 1 black male.

Program of Instruction

Curriculum

The goal of the ATC program at UAA is to produce graduates who are able to function as a terminal controller at a Level I (VFR) facility or as a radar associate in an en route facility. UAA program administrators and regional officials favor an earlier model for the CTI-ATCS program wherein the collegiate

programs provide basic (i.e., undergraduate) training to prepare students for an entry-level job at lower level facilities, such as a VFR terminal typical in Alaska. At some later point in their ATCS career, they would then attend the Academy for advanced (i.e., graduate) training to prepare them for a job at a higher level facility, such as those in Anchorage International Airport.

The UAA curriculum has evolved through the process of delivering and modifying instruction in ATC for more than 20 years. Because the curriculum is not the product of a systematic training development effort, the FAA requested in 1992 that UAA examine their curriculum with respect to critical skills and knowledges trained under the old Academy Screen. The analysis indicated that most of these critical skills and knowledges were currently being trained in the curriculum; only minor course revisions were needed to correct the omissions.

The required coursework, detailed in Table 9, is designed to be completed in two academic years (i.e., four semesters) although some students take longer to complete the program. The curriculum calls for 46 credit hours of required coursework in ATC. In addition, UAA requires the following credit hours in non-ATC courses: (a) three hours in oral communications, (b) six hours in written communications, and (c) six hours of general coursework (humanities, math, natural science, or social science). Thus, a total of 61 credits are required to graduate with the degree of Associate of Applied Science (A.A.S.). Students wishing to complete a four-year program can apply all credits earned in the ATC program towards a Bachelor of Science, Technology (B.S.T.) in Airway Sciences.

The first year of the curriculum is devoted to providing classroom instruction on basic skills and knowledges that are prerequisites to controlling air

Table 9

Required Coursework for the A.A.S. in Air Traffic Control at the University of Alaska, Anchorage

| Year | Course Code | Course Title | Credit Hours |
|--------|-------------|--|--------------|
| First | AT 140 | Air Traffic Control History | 3 |
| | AT 141 | Aviation Weather | 3 |
| | AT 142 | Control Environment | 3 |
| | AT 143 | Air Traffic Control Regulations | 3 |
| | AT 144 | Air Traffic Control Airborne Lab | 2 |
| | AT 145 | Principles of Flight | 3 |
| | AT 146 | Air Traffic Control Intern Program | 4 |
| Second | AT 200 | Instrument Ground School | 4 |
| | AT 240 | Operations in Flight Service Station | 3 |
| | AT 241 | Airport Traffic Control | 3 |
| | AT 242 | Proc. for Control of Instr. Traffic (PCIT) I | 3 |
| | AT 243 | Proc. for Control of Instr. Traffic (PCIT) II | 3 |
| | AT 244 | Proc. for Control of Instr. Traffic (PCIT) III | 3 |
| | AT 245 | Pilot/Controller Techniques | 3 |

traffic. The first year includes academic instruction in ATC history, regulations governing ATC, aviation weather, and basic air navigation techniques. The first-year series also includes an internship that incorporates field trips to local FAA air traffic facilities. This internship is designed to provide an early introduction to ATC problems that are peculiar to Alaskan airspace.

The emphasis in the second year is on learning specific ATC procedures and applying them under realistically simulated conditions. AT 241 (Airport Traffic Control) provides prerequisite instruction on terminal controller procedures, which are then practiced in the simulated facility (Weatherford Airport) used in AT 242 (PCIT I). PCIT I also provides instruction on basic non-radar control techniques. In contrast, AT 243 (PCIT II) disseminates information on basic en route radar techniques, which are practiced on radar simulations in AT 244 (PCIT III). Also included in second-year courses is AT 240 (Operations in a Flight Service Station). This course is designed to provide the student controller background knowledge on the flight service station (FSS). It is also helpful to the student who is too old for employment as a controller but may be eligible for a position in an FSS.

Terminal Lab

Despite the program's emphasis on Level I skills, terminal controller skills are trained in the context of a fictional Level III facility: the airspace around "Weatherford International Airport." Procedures are learned in a lab using scale model aircraft and the runway configuration painted on the floor. This laboratory is similar in layout and function to the "table tops" facility at the FAA Academy and Hampton University.

Radar Lab

Radar skills are trained with the ATCoach® system. The latest version of ATCoach® was installed after the end of spring semester and was not yet functioning at the time of the site visit. The capabilities of the system are assumed to be similar to those described for the ATCoach® systems at the CTI-ATCS programs at HU and MnATCTC.

Flight simulation

A key component of UAA's training program is the flight simulator, which is incorporated in two ATC courses. The simulator is a Frasca 141

GAT-1B, which is a single-engine, general aviation trainer that simulates IFR conditions only. This simulator has been in use in these courses and in other flying courses at UAA for more than 20 years.

Planned innovations

Several new training technologies are planned for the UAA program but have not yet been implemented:

1. With the help of the FAA board of advisors, UAA is planning to build and operate a VFR tower at Birchwood Airport in the northern part of the municipality of Anchorage. Along the lines of the CTI-ATCS program at CCBC, the intent is to provide students hands-on experience controlling air traffic while in the ATC program. Action on this initiative awaits the resolution of several issues, not the least of which is the acquisition of funding for constructing the tower.

2. Administrators are also seeking to acquire a three-window, part-task trainer for simulating terminal facility operations. Program administrators are now examining candidate systems to be acquired under the recently awarded Airway Sciences grant. The present cost goal for this system is less than \$500,000.

3. Long-range plans for the UAA program include the incorporation of ATC and other Aviation Sciences courses in UAA's distance delivery system. This system represents a collection of related training technologies (e.g., video instruction, satellite delivery, multi-media computer systems) that enable college instruction to be delivered directly to rural Alaskan citizens at some local site. This goal will probably not be realized until late 1996.

Class size

As of February 1993, 50 students were enrolled in both classes of the ATC program. Because of the open enrollment policy, program administrators expect considerable attrition in the first year. The ideal size for the program is about 20-30 students for first year and 15-20 for the second. However, UAA program administrators are anxious to avoid training more

students than the FAA can hire and are willing to adjust that figure downward given reliable projections of FAA hiring policies.

Instructors

The ATC program presently has only one full-time instructor—the program director. The university is seeking authorization for an additional full-time instructor. At the time of our visit (June 1993), the authorization had received approval by the Alaska state legislature and was awaiting the Governor's signature.

In 1992-93, the program employed five part-time instructors. The part-time employees include three active FAA controllers who teach ATC procedures. Two additional part-time instructors are used to teach the first-year introductory courses: One has a Ph.D. in human factors; the other has a background as a commercial professional pilot. Each semester, instructors receive in-service training through the university on topics related to instruction, such as coping with different student personalities/learning styles, and discussions of the pros and cons of different testing techniques.

CHAPTER 4 CONCLUSIONS AND RECOMMENDATIONS

The following discussion presents our conclusions regarding the present status of the CTI-ATCS demonstration program, and recommendations for improving its management and operation. The comments are based on the authors' observations and some of the responses to the subjective questions put to the program administrators. Unless otherwise specified, the comments are intended to apply to all five programs.

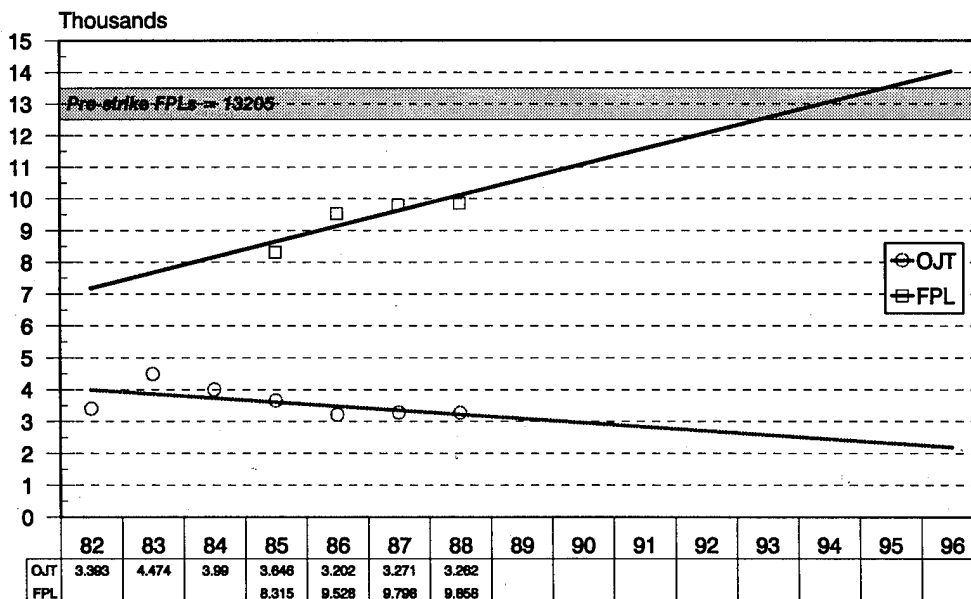
THE DEMAND FOR CTI-ATCS GRADUATES HAS BEEN SHARPLY CURTAILED

In the interviews, the administrators of the five collegiate programs recognized that the greatest threat to and most serious problem for the CTI-ATCS program is the reduction in demand for newly trained controllers. The hiring rates characterizing the early 1980s were expected to continue for many more years when the CTI-ATCS program was first conceived in 1988. For example, a draft proposal circulated by the Mid-America Aviation Resource Consortium (MARC, later renamed MnATCTC) in 1988 projected a "...need

for 2,000 ATC specialists per year *for the next ten years*" [italics added]. In other words, MARC projected that the FAA would add between 1988 and 1998 about 12,000 controllers (after losses at the FAA Academy and in field training) to its staff of almost 10,000 full performance level (FPL) controllers.

The perception of a significant hiring requirement appears to have been widely shared throughout the aviation education community, the Congress, and the FAA itself in the mid- and late-1980s. However, data available as early as 1989 from the CAMI ATCS Training Tracking Data Base, maintained under FAA Order 3120.22A, as well as a 1989 report published by the General Accounting Office (GAO), suggested otherwise. Data from these sources are summarized in Figure 1. These trends suggested that ATCS hiring requirements were likely to be reduced by about FY 1993 as the FPL controller workforce was rebuilt to its pre-strike strength of about 13,000. In other words, analysis of available data might have suggested that the collegiate programs were planning to produce

Figure 1. Trends in the ATCS workforce based on GAO and CAMI data available in 1989.



products (graduates) just at the time when the market for those products was (at best) mature, and (at worst), shrinking. Analysis of GAO and CAMI data through 1991 (Figure 2) only confirm the projections from 1989 data: There was likely to be a smaller market for CTI-ATCS graduates in the 1990s than had been anticipated. FAA controller workforce requirements have been even further reduced by the age distribution of the rebuilt controller workforce, which has suppressed attrition due to retirement. Moreover, the recent trend toward flattening the ATCS management structure has reduced attrition due to promotion. As a consequence of these three factors, the demand for new entry-level controllers has been sharply reduced, and as a result, graduates of the CTI-ATCS institutions are experiencing significant delays in getting hired by the FAA. This is especially problematic for the schools that attract older students who may be close to the age-30 hiring restriction.

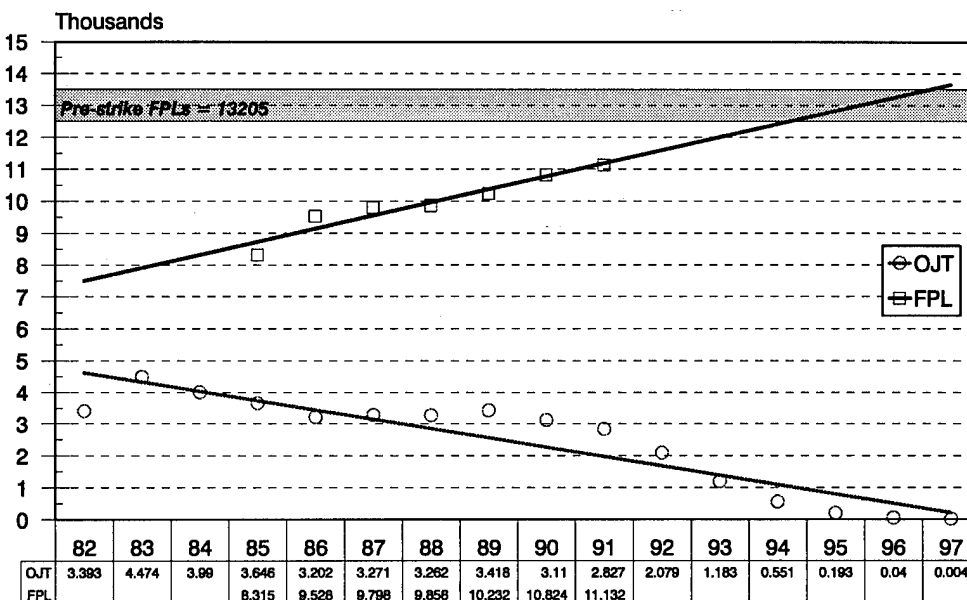
In response, program administrators want a greater commitment from the FAA to hiring and placing CTI-ATCS graduates. Some of the administrators are willing to reduce the numbers of students that they train in exchange for that commitment. Their prob-

lem is getting from the FAA accurate, timely projections of the need for new controllers for planning purposes. Clearly, the numbers of students dictate some of the essential parameters of their programs, such as the numbers of instructors, simulators, classroom space, and so on. To plan for these reductions, the FAA needs to provide accurate projections of the number of new controllers that it will need and to allocate those slots among the five institutions. Furthermore, these projections should provide estimates for at least five years into the future to plan for the next year's incoming classes at the four-year institutions. These projections should then be updated as developments occur. For instance, the projections should consider the impact of ex-PATCO controllers who are now allowed to compete for jobs in the FAA.

THE PROGRAMS *APPEAR* TO BE FUNCTIONING WELL

All five CTI-ATCS programs are currently in operation and *appear* to be functioning well. Several observations led the evaluators to this conclusion. First, each of the administrators projected a sense of having clear training goals and reasonable strategies for reaching those goals. The confidence of the ad-

Figure 2. Trends in the ATCS workforce based on 1982-1991 GAO and CAMI data. (OJT figures for 1993 and beyond are projected.)



ministrators in their own programs was evidenced by their unanimous responses (a) that their ATC programs were as good as or better than the FAA Academy's and (b) that their graduates would be well accepted in FAA facilities. Second, in addition to a clear vision of program strategies and goals, the administrators evidenced attention to the tactical details of running a CTI-ATCS program (e.g., remediation policies) that were not spelled out in their initial agreements with the FAA. Third, the programs are operating satisfactorily without the benefit of vast resources in equipment and instructors. Overall, our impression is that the individual CTI-ATCS programs have quickly acquired the knowledge and experience necessary to train ATCSs in a collegiate context. The FAA needs to tap that experience and act more in partnership with the institutions to determine the future of the CTI-ATCS program.

We purposely emphasize the term "*appear*" to indicate that these comments are largely based on our subjective reactions to the CTI-ATCS programs, rather than on objective fact, that is because it is not known at this point if the schools are producing graduates who are ready for training at an FAA facility. As graduates are absorbed into the system, their performance must be documented to amass the sort of evidence required to mount a summative evaluation of the program.

PROGRAMS ARE EMPLOYING INNOVATIONS IN RECRUITING, SELECTION, AND TRAINING

One of the principle purposes of the CTI-ATCS demonstration program was for the institutions to develop and implement innovations in ATC recruiting, selection, and training. Even a cursory examination reveals that the CTI-ATCS institutions have developed methods and technologies that are different from the FAA and different from each other. Some of the innovations observed at the institutions are summarized briefly in Table 10. (More detail on these and other innovations was provided in Chapter 3.) This table documents that, as mandated in the original FAA order, the CTI-ATCS institutions are in fact developing and implementing diverse approaches and technologies related to ATC training.

As encouraging as these innovations may sound, this does not imply that they are necessarily effective. At the least, however, the innovations imply a variety of hypotheses that can eventually be tested. For instance, does the team training at HU actually improve controller efficiency in a realistic work environment? Does the tower training provided at CCBC facilitate transition to tower operations on the job? CAMI should work with the institutions to design research for testing these, and other hypotheses, as a part of the future summative evaluation.

PROGRAMS ARE CONVERGING ON SOME COMMON APPROACHES TO ATC TRAINING

Whereas the programs evidence diversity in innovations, the programs have also developed some commonalities in their approaches. These common themes may have resulted from communication and cross-fertilization of ideas among CTI-ATCS institutions. The adoption of the approaches from other programs also demonstrates that the collegiate ATC programs are starting to model one another, rather than attempting to duplicate the FAA Academy. This trend could encourage the development of innovative approaches to ATCS training. The following provides a discussion of some of the common innovations that are presently implemented, or are planned to be implemented in the future, at two or more programs.

Low-Cost Simulation Systems for Radar Training

The programs have all adopted relatively low-cost radar simulation systems based on networks of personal computers. The system at CCBC was developed especially for them by Wesson, whereas the system at UND (Virtual Controller) was developed by UND personnel. The remaining three institutions use the same system: ATCoach® developed by UFA. A systematic examination of the ATCoach system at MnATCTC was performed by the FAA in 1992. The FAA evaluators noted 66 deviations from full fidelity, 49 of which were rated as "critical." At the same time, they noted that the Academy's high-fidelity VAX-based Radar Training Facility (RTF) also deviates from full fidelity: Of the 49 critical deviations noted in the ATCoach® software, 8 similar deviations were

Table 10

Examples of Innovations Identified at Each of the Five CTI-ATCS Institutions

| Institution | Innovations |
|---|---|
| Minnesota Air Traffic Control Training Center (MnATCTC) | <ul style="list-style-type: none"> development and use of unique criterion-related selection instrument use of computer-based ISD software to develop program development of CBI courseware that complements curriculum incorporation of team training to improve management as well as controller skills |
| Hampton University (HU) | <ul style="list-style-type: none"> active recruitment of female and minorities systematic methods for screening applicants incorporation of team training to improve controller interactions library of locally developed CBI courseware |
| Community College of Beaver County (CCBC) | <ul style="list-style-type: none"> incorporation of actual tower training in curriculum use of BC Airport controllers as instructors pilot orientation regional interest in program |
| University of North Dakota (UND) | <ul style="list-style-type: none"> locally developed ATC simulation active recruitment and outreach to Native Americans development of administrative and managerial skills pilot orientation |
| University of Alaska, Anchorage (UAA) | <ul style="list-style-type: none"> female/minority scholarship flight orientation with regional focus use of FAA controllers as instructors active regional involvement in program |

noted on the RTF software. Although the RTF may offer a higher fidelity simulation of radar functions, the acquisition of such a high-fidelity system such as the RTF would be cost-prohibitive for institutions in the CTI-ATCS program. Thus, these low-cost systems continue to be a reasonable choice for the CTI-ATCS institutions.

Chunk-and-Apply Approach to Instructional Design

Three of the CTI-ATCS instructional programs (MnATCTC, HU, and UND) present students with practical exercises in controlling aircraft as early as possible in training. This training design is consistent with an instructional design principle that training developers at the FAA Academy call "chunk and apply." This training strategy specifies that related knowledges and skills must be trained together (i.e., as a chunk), closely followed by their immediate application in a realistic problem. Because this approach is currently in use at the Academy, it is not, strictly speaking, an ATC training innovation. Nevertheless, it represents convergence toward a modern approach to instructional design that is consistent with modern information processing theories of learning and memory. (For discussions of the implications of information processing theory to ATC training, see Means et al., 1988; and Schlager, Roth, Rolling, Mumaw, & Gagné, 1989.)

Pilot Perspective in ATC Training

Three of the CTI-ATCS programs recognize the value of learning the pilot's perspective in controlling air traffic: UAA requires their students to take four courses related to flying, including ground instruction in a simulator; UND and CCBC require that their students actually obtain a private pilot's certificate. Conversations with Academy administrators indicated that they, too, think the students' understanding of the pilot's perspective of ATC is worthwhile. However, pilot training cannot be implemented at the Academy within the current time and resource constraints. Thus, this sort of extensive background instruction is a unique advantage of these CTI-ATCS institutions.

Training in Team Skills

Both MnATCTC and HU have incorporated explicit training in team skills, although their emphases are different. At MnATCTC the emphasis is on team-building skills in preparation for management and controller positions, whereas the focus at HU is on the controller's work to improve interaction between pilot and controller, as well as among controllers. Despite these differences, both programs recognize the importance of team skills in the ATC profession. As discussed above, however, it remains to be seen whether training in team skills has a positive effect on job performance at either the controller or manager level.

Hands-On Training in VFR Tower

As identified in Table 10, one of CCBC's most important innovations is their use of the VFR control tower at Beaver County Airport to train their CTI-ATCS students. This is an important innovation in that it allows students to apply the knowledges/skills they learned in class and labs in an actual job setting. UAA recognizes the advantages of the control tower at CCBC, and has begun to explore the possibility of building a similar operational tower for training students.

Distance Learning Technologies to Reach Remote Populations

Both UND and UAA are trying to recruit and train rural citizens (particularly Native American populations) who are located largely in remote and isolated communities. These citizens are often reluctant to move from their homes to a residential campus. A strategy is evolving at both schools to export some aviation-related courses to students at the remote sites. In addition to providing instruction in aviation-related subjects, it is hoped that these courses will facilitate the rural student's eventual transition to campus life.

INSTRUCTOR CURRENCY IS NOT A SERIOUS PROBLEM

When asked to identify their most important assets, administrators of the CTI-ATCS institutions all identified their knowledgeable and dedicated faculty. At the same time, FAA Academy personnel had specu-

lated that a problem in the CTI-ATCS program might be the currency of instructor knowledge and experience, because they all were thought to be retired FAA and military controllers. In fact, some of the five programs do, in fact, employ retired controllers. However, the institutions all cited their respective FAA regions as being helpful in keeping them current in FAA rules and regulations. In addition, CCBC supplements retired controllers with active, non-FAA controllers who work full time at the Beaver County Airport. UAA is the only program that does not use retired controllers; instead, they employ a few active controllers from the Alaska region to teach part-time at the school. The relationship at UAA appears satisfactory to both the school and the region, and effectively eliminates the problem of instructor currency.

SOME PROGRAMS HAVE MADE PROGRESS IN RECRUITING FEMALES AND MINORITIES

One of the purposes for developing collegiate ATC programs was to attract females and minorities to the profession. Some (not all) of the CTI-ATCS institutions have made significant progress in that regard. In particular, the programs at MnATCTC and HU have actively recruited and trained female and African Americans in their programs. UND and UAA have actively sought out Native American students but thus far have been less than successful in recruiting them to their program. Although some limited progress has been achieved, it should be noted that the programs will have only limited impact on the diversity of the controller workforce, particularly in light of the anticipated reductions in students being trained in CTI-ATCS institutions.

PROGRAMS DO NOT MAINTAIN CONSISTENT STUDENT DEMOGRAPHICS

Some of the programs (MnATCTC and HU) keep detailed student demographics; however, they differ in the type and format of student demographic information they maintain. A couple of institutions (CCBC and UAA) do not regularly maintain detailed records at all. Without detailed and consistent demographic information, it is difficult to assess the progress that the programs are making to recruit females and minorities. This situation may improve when the FAA's

Office of Aviation Careers begins to track CTI-ATCS students. The plan is for this office to track all CTI-ATCS students, starting when they enroll in the collegiate programs. The purpose is to keep track of the students' progress in completing FAA requirements and to market the students to the regions when they graduate. Using MnATCTC and HU as a model, it is encouraged that all CTI-ATCS institutions maintain demographic data on students, consistent with a common data base. In particular, it would be helpful if the information on student ethnic background was coded consistently across the schools.

PROGRAMS WERE DEVELOPED FROM DIFFERENT JOB ANALYSES OR NO ANALYSES AT ALL

Despite some commonalities in instructional design (e.g., the chunk-and-apply approach), the individual programs are based on different job analyses or no analyses at all. Job analyses are commonly regarded as a necessary initial step in the development of training and performance measurement technologies. Some programs simply skipped this step, relying instead on existing curricula or their own subject matter expertise. Other programs performed their own analyses or modified FAA task documentation. The lack of a common job analysis is reflected in the diversity of terminal objectives provided by the institutions. Using the terminal option as an example, the final learning objective ranges from performance equivalent to the requirements of a Level I VFR facility to performance expected at a Level V facility.

This criticism begs the question whether or not the schools should have performed their own analysis of the controller's job. We think not. We assume that all of the programs are training students for the same ATCS job. Therefore, they should all be based on a common set of requirements for the controller's job. Without a common set of training requirements, the FAA does not know the basic skills and knowledges that CTI-ATCS graduates bring to the job. Therefore, we recommend that a single, common job analysis be accepted by the FAA and that each of the institutions link the analysis to their educational programs.

The FAA is already moving in that direction. In August 1993, the FAA sent all CTI-ATCS institutions a letter outlining the training objectives (job

skills and tasks) and subject areas (factual knowledge) currently being trained at the FAA Academy. Programs were advised that their curricula "... shall, at a minimum, contain the same subject areas and meet the same training objectives ... as the FAA Academy curriculum." Although this listing of objectives and subject areas is not a comprehensive job-task analysis, it provides some of the much-needed information provided in such an analysis, namely a listing of the skills and knowledges required to begin OJT at an ATC facility. Each of the CTI-ATCS programs should formally respond to the document, including any omissions that are evident from their own analyses or their experience training ATC subjects.

THE OPM TEST IS NOT USED TO SELECT STUDENTS

Unlike the FAA, the CTI-ATCS institutions do not use the OPM test as a selection instrument. Rather, the programs encourage their students to take the test at the end of their coursework. The institutions point out that delaying the test increases the chances of earning bonus points for knowledge of aviation and lengthens the period of time that the scores are valid. Indeed CCBC pointed out that their typical incoming students are not eligible to sit for the exam. Nevertheless, the OPM test was designed to measure aptitude for the ATC profession, not to serve as a measure of what is learned in training. Therefore, the OPM test should be scheduled to be taken as early as possible in a student's course of study to determine if they are good prospects for the controller's job. At the same time, processing the OPM test requires some period of time. If students take the test at the end of their coursework, they are likely to experience a delay in hiring. A reasonable compromise appears to be the procedure used at MnATCTC, wherein students take the OPM test about halfway through their coursework. This allows enough time to process OPM test data, as well as security and medical information, to be completed by the time the student graduates.

INSTITUTIONS DO NOT UNDERSTAND THE REQUIREMENTS OF THE PERFORMANCE VERIFICATION

In addition to successfully completing training objectives, students must demonstrate their attainment of the knowledges and skills required for OJT by

successfully completing performance verification (PV). At the time of our interviews, the requirements for the PV exam had not been detailed by the FAA, and the institutions had literally no idea of the content of this test or how it would be implemented in their programs. A model performance test (perhaps the one administered at the FAA Academy) is needed to demonstrate the test content and procedures to the CTI-ATCS programs. This model and the list of training objectives and subject areas described above should provide enough grist for the CTI-ATCS programs to develop performance exams that can reasonably be administered at their facilities.

THE EFFECTS OF COMBINED TERMINAL/EN ROUTE CURRICULA ARE UNKNOWN

UND, CCBC, and HU all offer both terminal and en route options. Unlike the FAA Academy, students in these programs are not assigned to one or the other option; rather, they receive instruction on both career options. It could be argued that this single curriculum is a waste of training time, because students will be assigned as either a terminal or en route controller—not both. On the other hand, it could be argued that training in both options provides valuable knowledge about and an appreciation for the job of other controllers with which any controller must interact. Whether or not this cross training is beneficial to performance should be a topic for the summative phase of this ongoing evaluation. The FAA also needs to consider the implications of such cross training for controller career paths. For instance, the FAA needs to consider whether or not CTI-ATCS graduates from programs offering both options be allowed to change career paths, that is, from terminal to en route controller jobs or vice versa.

MANAGEMENT OF THE CTI-ATCS PROGRAM SHOULD BE IMPROVED

More than one program administrator commented that communications with FAA headquarters was sporadic and that decision making was extraordinarily slow. Part of the problem seems to be FAA's matrix management method that seeks to involve a cross-section of organizations directly affected by the CTI-ATCS program. Our discussions with FAA employees

revealed another, more fundamental, problem: some apparent ambivalence of the FAA towards the CTI-ATCS program itself. The FAA, might consider appointing a single manager of the CTI-ATCS program who is knowledgeable about the details of each institution and is a forceful advocate of the program within the FAA. Furthermore, this manager could serve as the conduit of all communication between all FAA organizations and the programs, but have the power to make operational decisions affecting CTI-ATCS, without necessarily consulting the entire steering committee.

**THE CTI-ATCS PROGRAM IS GENERALLY
SUCCESSFUL, BUT FURTHER STUDY IS NEEDED**

In summary, the CTI-ATCS program was conceived as a bold initiative in ATC training. In large part, the initiative has succeeded. The individual programs developed at the five nonfederal post secondary institutions have demonstrated that they can develop, deliver, and implement air traffic control recruiting, selection, and training programs. Furthermore, the programs have developed and implemented thought-provoking innovations in ATC training. These encouraging observations should be tempered by cautioning, once again, that the training effectiveness of the programs has yet to be measured by summative evaluation techniques.

Despite the apparent overall success of the program, there have been difficulties in the administration and management of the program at the level of both the local institution and the FAA. The schools still have problems specifying precisely what their courses train and what their students are learning. Also, the institutional recruiting programs have been less than fully successful in recruiting large numbers of women and minorities. From the management side, the FAA has at times failed to communicate effectively with the institutions and to make timely decisions that affect the future of the program. Some

of the reticence of the FAA management may be traced to their ambivalent attitude toward the CTI-ATCS program as a whole. These problems are not insurmountable and can be corrected through actions taken at the institutional or federal level. However, these corrections will require close cooperation between the institutions and the FAA, with an eye toward explicit goals for the program.

The most serious problem facing the CTI-ATCS is the reduction in demand for new entry-level controllers. Unlike the other problems discussed above, this problem is not easily addressed by actions at the institutional or federal level. Moreover, it brings into question one of the fundamental assumptions of the program: that the FAA will continue to hire these newly trained controllers. CTI-ATCS graduates are currently experiencing significant delays in hiring, and the situation appears to be getting worse. It is incumbent upon the FAA to determine whether or not there is enough demand for newly trained controllers to support five different CTI-ATCS institutions and the FAA Academy. If not, the role of the CTI-ATCS institutions must be reexamined vis-à-vis the FAA Academy and the entire ATC training system. For instance, the FAA might examine whether the CTI-ATCS institutions take on other functions, such as providing refresher training and college-credit programs for the FAA regions. Alternatively, the FAA might explore the possibility of redefining the Academy's role; for instance, UAA has suggested that the CTI-ATCS institutions provide all initial training with the Academy taking on the function of a graduate school of air traffic control. These possibilities are not meant to be exhaustive or even representative. Rather, they are meant to suggest the wide range of questions and alternative actions that the FAA should consider with respect to improving the CTI-ATCS program, a program that otherwise has promise in providing innovative ATCS selection, recruiting, and training.

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APPENDIX A

Questions for Administrators of CTI-ATCS Institutions

Name:

Title:

Phone Number:

1. I want to start by getting some basic information about your program.
 - a. Prior to the ATCS program, did you have an Airways Sciences program in place? How long has it been in existence?
 - b. Does your CTI-ATCS program focus on the en route option, the terminal option, or both?
 - c. How many students have graduated from the CTI-ATCS program? Where have they been placed?
 - d. What is your present rate of graduation? Do you expect that to increase or decrease in the near future?
 - e. What are the tuition and other costs that the students must pay?
2. I have some questions about your overall goals for the program.
 - a. According to your understanding of the CTI-ATCS program, what are the minimal objectives that all five CTI-ATCS programs must meet? Prioritize these objectives.
 - b. What unique objectives does your program strive to attain? What are their priorities relative to the common objectives that you just described?
3. The next questions pertain to your acceptance policies.
 - a. Describe how students apply to your program.
 - b. What are your criteria for acceptance?

4. Related to acceptance issues are two FAA-mandated selection instruments.
 - a. How does the OPM written test fit into your program, and does it determine who you accept or retain in the program?
 - b. How does the FAA five-day computer-based screen fit into your program, and does it determine who you accept or retain?
5. The next questions relate to your recruiting strategies.
 - a. What sorts of recruiting strategies do you have to attract students to your program?
 - b. I'm particularly interested in how you attract students to attend your CTI program and pay tuition when students at the Academy are, in essence, paid to attend their program.
 - c. Do you have any specific Affirmative Action (i.e., diversity goals)?
 - d. What strategies are you using or plan to use in attracting, retaining, and graduating women and minorities?
6. The next questions concern your curriculum.
 - a. Please describe your curriculum in general terms and tell me how it was developed. [Any printed materials would be helpful.]
 - b. Describe any training innovations that you have implemented or are planning to implement. ["Innovations" are defined relative to the Academy.]
 - c. What is terminal learning objective for the program? [What job will your graduate be able to perform immediately, or what level of job proficiency will they have attained at graduation?]
7. I have some specific questions regarding your instructional staff.
 - a. How many instructors do you currently employ?
 - b. What is their background?
 - c. Does your staff have FAA controller experience? How recent is that experience?

- d. How do they keep abreast of changes in the ATC profession?
 - e. Do your instructors receive any instruction on "training to train?"
8. The next questions concern your communications with the FAA regarding your CTI-ATCS program.
- a. How do you communicate with FAA?
 - b. Does the FAA try to keep you abreast of changes to the ATC profession?
9. The following questions concern your personal expectations about your graduates.
- a. Do you expect your students to be fully accepted in field training?
 - b. How do you expect they will fare (relative to Academy graduates) in over the longer (career) term?
 - c. Do you expect your students to remain in this geographic area once they start their ACTS careers?
10. Finally, I have some questions to elicit your personal evaluations of the program here.
- a. In your opinion, how does your program compare with the FAA Academy?
 - b. Do you see your program as competing with other CTI programs for students, funding, FAA attention, and so on?
 - c. What are particularly attractive features of your program vis-a-vis the other CTI-ATCS programs?
 - d. In general, what are your program's greatest strengths (weaknesses)?